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Iso-Butane
Butane
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Hexane
Heptane
Heavy Naphtha
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QUICKER STARTING
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GREATER SPEED
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SMOOTHER ACCELERATION

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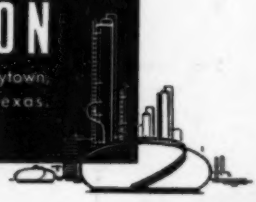

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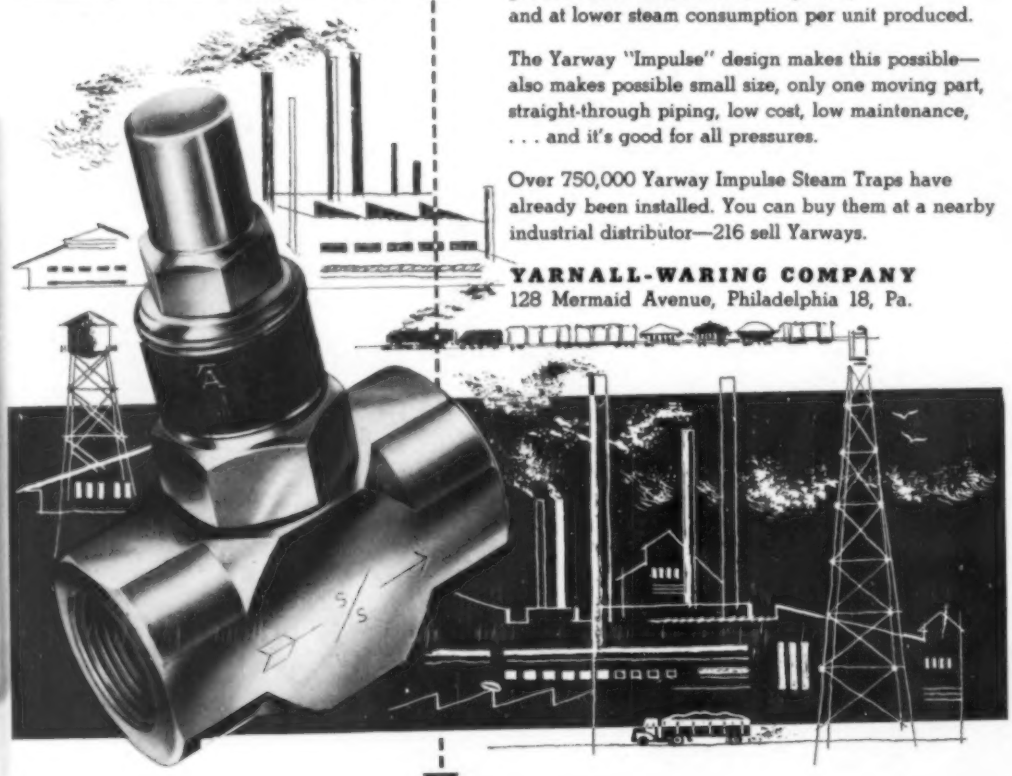

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PETROLEUM REFINER

Specialized for Refining, Natural Gasoline and Petrochemical Engineering, Operation and Management

R. L. DUDLEY, President — A. L. BURNS, General Manager

VOLUME 30, NO. 8 — AUGUST, 1951

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In Control Valve Bodies*, too—

The C_Q Method Reveals All the Quality Factors

The C_Q Method enables you to select control valves conveniently — with an accurate analysis of comparative value. First, set a standard of quality; then evaluate *all* the quality factors in relation to your standard. The sum of the value of the quality factors is the C_Q (Quality Coefficient).

"It isn't the first cost — it's the upkeep" is true of control valves. The over-all cost — the real cost — includes maintenance and operation delays in addition to the purchase price. Thus, among comparably priced valves the best buy is the one with a high C_Q — because for comparison purposes

$$\text{Real Cost} = \frac{\text{Price}}{C_Q}$$

"A high quality product provides accurate performance over a long period with a minimum of maintenance and operation delays."

In other words, it has a high C_Q. Use the C_Q Method in selecting *your* control valves.

*This analysis of the valve body assembly is only half the story; write for your copy of an analysis of the diaphragm motor.

Check For These Quality Factors in the Body Assembly

Performance Factor

Flow Characteristics Correct for the Service
Alignment of Parts for Positive Operation and Response
Friction Minimized by Design of Guides, Stuffing Box, Packing, and Plug Stem Finish
Large Body Flow Passage Areas
Long Valve Stroke
Cv (Flow Coefficient) Rating

Mechanical Construction Factor

Strength of Bonnet Construction
Precautions against Seat Ring Distortion
Valve Plug-to-Stem Fastening
Guide Design for Strength and Service Life
Precautions against Misalignment of Parts
Flange Gasket Design
Lubricator Design for Efficiency, Strength, Safety
Stuffing Box Assembly Design
Strength of Bonnet and Blindhead Bolting
Availability of Suitable Body and Trim Design and Materials for the Service
Ability to Withstand Rough Handling

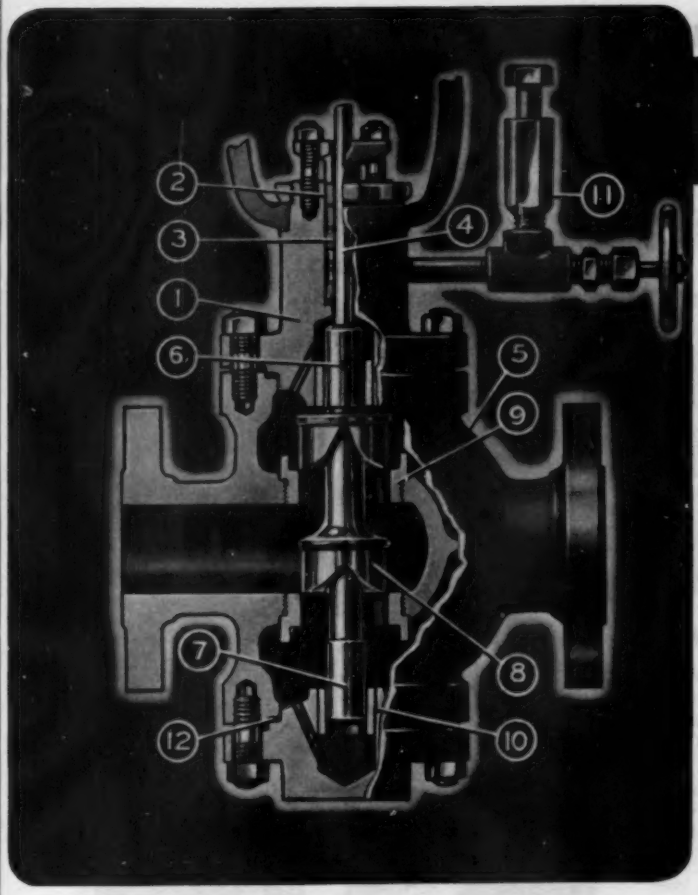
Convenience Factor.

Choice of Body and Trim Materials
Selection of Standard Valve Plug Types
Availability of Standard Reduced Capacity Trim Design
Choice of Standard Packing Materials
Availability of Variety of Bonnet Designs
Standardization of Face-to-Face Dimensions

Maintenance Factor

Ease of Detaching Diaphragm Motor
Ease of Accurate Reassembly after Servicing
Interchangeability of Comparable Parts
Ease of Reversing Plug to change Valve Action

See our Exhibit in Booths 214-216 at the Sixth National Instrument Exhibit, Sam Houston Coliseum, Houston, Texas, September 10-14, 1951.



For Example, Consider the Body Assembly of Masoneilan 10,000 Series Control Valves

1. **One-piece Bonnet** of forged or cast steel, with flange piloted in body for strength and accurate alignment. Heavy bolting for strength.
2. **Bolted Stuffing Box** construction on valve sizes 2" and larger. Threaded construction on smaller valves has five-thread minimum engagement, at no compression, for safety. Adequate box depth for sealing at low compression. Manufactured with special tools and gauges to avoid misalignment, and insure reproducibility and interchangeability of parts. Optimum clearances prevent packing flowing, while allowing for expansion over broad temperature range. Fine finish of gland and box surfaces maintains tightness between packing and box wall. Bonnet extension and air-finned construction available for extreme temperature service; bellows-sealed type for special applications. Bolted construction designed to permit removal of diaphragm motor without disturbing stuffing box.
3. **Four Packing Types** available for application according to service conditions: (1) preformed asbestos-and-binder solid ring; (2) braided-jacket, reinforced plastic core, split ring; (3) woven asbestos, †Teflon-impregnated, split ring; (4) solid †Teflon V-ring.
4. **Honed and Highly Polished Valve Stems** reduce stuffing box friction up to 65%; increase packing life; improve performance.
5. **Body** has large flow passages for minimum pressure drop; bridgewall section designed for heavy seat rings and optimum seat-to-seat distance for rated stroke; has uniform standard face-to-face dimensions in cast iron and steel types.
6. **Stem-to-Plug Fastening** by means of grooved, self-locking pin driven into pinhole drilled and reamed, in stem and plug simultaneously, while stem is threaded tightly into plug — insures tightness, prevents shearing pin.
7. **Heavy Valve Plug Guide** sections manufactured to very close tolerances — insures strength, accurate alignment, reproducibility, interchangeability.
8. **Choice of Plug Types** for practically all services. Includes Percentage Piston, Percentage Parabolic, Percentage V-Port with wide flow range, percentage characteristics. Also quick-opening and linear types, Point-4-Factor reduced capacity trim in solid and V-Port designs. Single and double seated. Interchangeable trim designs in comparable sizes. All types (except Percentage Piston) reversible in field to change valve action.
9. **Seat Rings** with heavy shoulders which prevent distortion; piloting at maximum ring diameter insures positive centering; narrow seating surface in bridgewall and long threaded section provide tight joint, prevent leakage. Four heavy lugs aid in removal and replacement.
10. **Long Guide Bushings** (steel valves) of hardened stainless steel in bonnet and blindhead have minimum clearance, assure accurate guiding.
11. **Lubricator** size is ¼" minimum for strength; has ball check valve. Forged steel isolating valve supplied with steel valves for added safety.
12. **Fully Retained Gaskets** of corrugated armco iron or special alloy for tightness and durability.

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†Teflon is a trademark of E. I. du Pont de Nemours & Co.

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Silmo	Sicromo 5	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	

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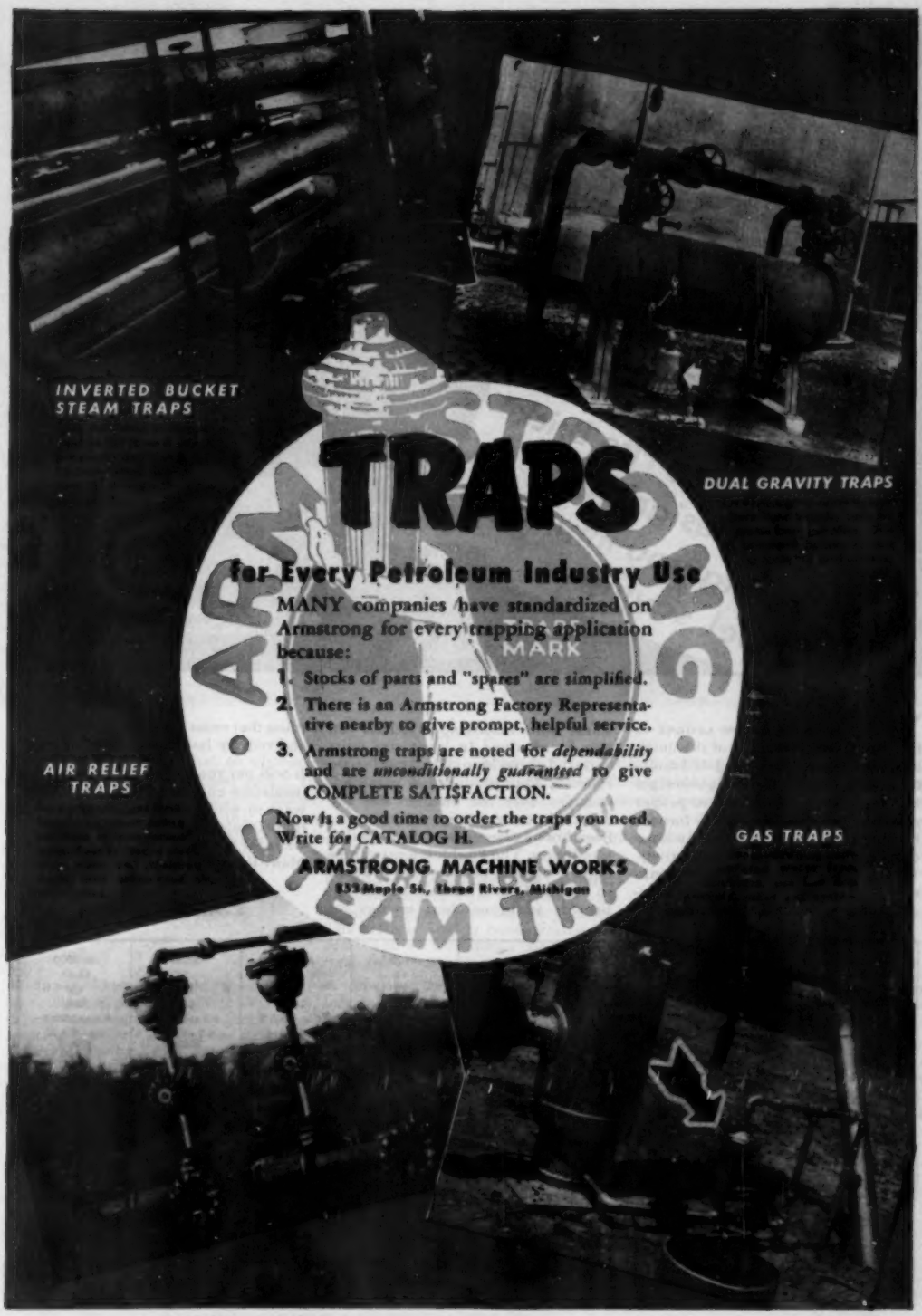
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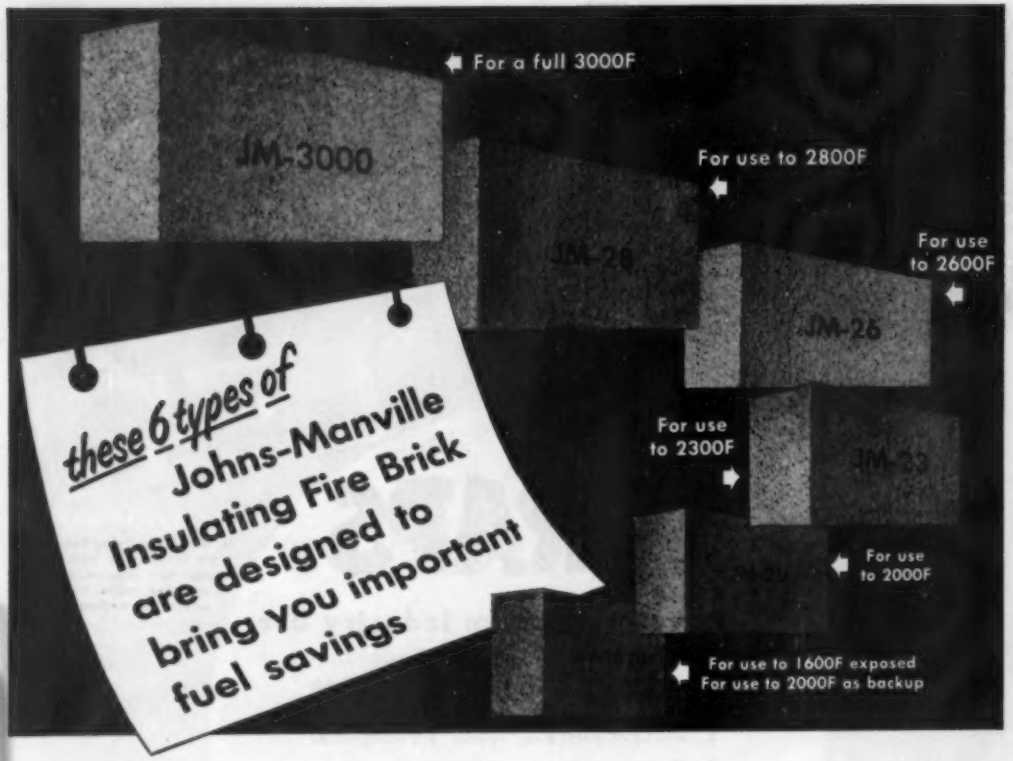

You can make important savings in fuel by taking advantage of the quick heating characteristics of J-M Insulating Fire Brick. These light-weight brick permit a quicker rise to proper operating temperature in the furnace because of their low heat storage capacity, and low thermal conductivity. Where furnaces are being intermittently operated these are two especially important characteristics.

These same insulating materials can also be obtained in large size units called Johns-Manville Insulating *Fireblok*. This product has many advantages over the smaller size fire brick for certain types of jobs . . . from both a construction and stability standpoint. The Fireblok units can be quickly applied because they are easy to cut and fit. Fireblok insulations provide additional heat savings because they reduce the number of joints, and require less mortar for bonding.

It will pay you to let a Johns-Manville insulation engineer explain the many ways in which you can save by using these insulations in your furnaces. Just write for further information to Johns-Manville, Box 290, New York 16, N. Y.

	JM-1620	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft	29	35	42	48	58	63-67
Transverse Strengths, psi	60	80	120	125	130	200
Cold Crushing Strengths, psi	70	115	170	190	150	400
Linear Shrinkage†, percent	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent	0.5—0.6 at 2000 F ↑	0.5—0.6 at 2000 F	0.5—0.6 at 2,000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F	0.77	0.97	1.51	1.92	2.00	3.10
1000 F	1.02	1.22	1.91	2.22	2.50	3.30
1500 F	1.27	1.47	2.31	2.52	3.00	3.35
2000 F	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up	2000 F	2000 F	2300 F	2600 F	2800 F	3000 F
Exposed	1600 F	2000 F	2300 F	2600 F	2600 F	3000 F

†24-hr. simulative service panel test for JM-3000; 24-hr. soaking period for other brick. *Conductivity is expressed in Btu in. per sq ft per F per hour at the designated mean temperatures. Note: Above tests are in accordance with A.S.T.M. tentative standards.

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Sulfur Shortage

Since sulfuric acid is vital to almost every industry, the current shortage of elemental sulfur, from which this acid is generally derived, is a serious matter and has a world-wide effect. Waste materials that can be converted into sulfuric acid and unworked sulfur bearing ores hold the answer to the sulfur shortage. Chemico offers proven processes for utilizing such sources of sulfur. If you have a source, in commercial quantities, of any of the following materials, please give us details. We will then be glad to make specific recommendations without obligation.

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3. Waste Iron Sulfate-Acid Solutions are by-products from steel mills and titanium pigment manufacturing plants. The sulfuric acid is concentrated for re-use and the iron sulfate converted to fresh sulfuric acid.

4. Smelter Gas results from metallurgical operations where sulfide ores are roasted preliminary to the recovery of metals. The gas is cleaned and processed into fresh sulfuric acid.

5. Coke Oven, Natural and Refinery Gases contain sulfur as hydrogen sulfide. This may be reduced to sulfur or extracted directly as a raw material for producing sulfuric acid.

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ALCOA

ALUMINUM

Published by Aluminum Company of America

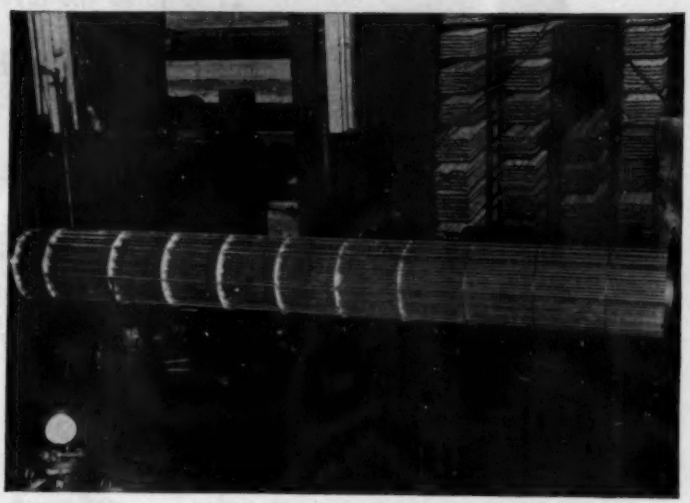
Rearmament needs severely limit the manufacture of aluminum heat exchanger tubes. But we realize that the purchase of refinery and processing equipment requires long study of economic and performance factors. That is the reason for this message.

El Paso Natural Gas Company Saves ⅓ in Cost of Glycol-Amine Exchanger Tubes

About three years ago, the Fluor Corporation started investigation in corrosion problems occurring with steel exchanger tubes in gas-treating plants utilizing Fluor's glycol-amine process. They conducted extensive research to find suitable replacements for steel. (Results of these tests were reported in the April, 1950, and February, 1951, issues of "Petroleum Refiner" Magazine.) Aluminum and 4-6 cr., ½ moly. steel tubes were most economical of the corrosion-resistant materials tested.

So when Fluor Corporation was selected to engineer glycol-amine exchangers at one of the large new plants of El Paso Natural Gas Company, they recommended Alcoa 3S-H14 aluminum tubes for the service. These tubes cost 30 per cent less than seamless mild steel and 60 per cent less than 4-6 cr., ½ moly. steel. Fabrication of the units was done by Griscom-Russell.

Aluminum heat exchanger tubes have been so successful in resisting corrosion in glycol-amine plant service that over 100,000 pounds of aluminum are now used in that service. Experimental work has indicated over one year of service



with no sign of corrosion. In handling, shipping and fabricating costs, the aluminum tubes saved 200,000 pounds over the heavy metal tubes they replaced. Their greater ductility permits easier roll-in.

ALCOA OFFERS BOOKLET

"This 24-page booklet will answer many of your questions about Alcoa Tubes. It covers fabrication techniques, alloy selection, chemical and petroleum applications. It describes tube cleaning, inhibitors, cathodic protection. It contains complete information on fluid flow and heat transfer. There are formulas, tables and specification data. Write for your free copy today. ALUMINUM COMPANY OF AMERICA, 1864H Gulf Bldg., Pittsburgh 19, Penna.

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Condensers handling hydrocarbon fractions such as gasoline, naphtha, gas, oil, etc.
Vapor recovery condensers
Lube oil coolers
Natural gas compressor aftercoolers
TCC overhead condensers
Recompressor aftercoolers
Hydrogen sulfide gas coolers
Furfural condensers and heat exchangers
Propane chilling
Wax sweaters
Lean oil—rich oil exchangers
Amine solution coolers
Glycol-amine solution coolers and heat exchangers.

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Ethanol
Ethylene Glycol
Glycerin
Hydroabietyl
Isopropanol
Methanol
Phenol
Propylene Glycol
Acetaldehyde
Formaldehyde
Furfural
Heptaldehyde
Acetic acid
Butyric acid
Stearic, Palmitic, Maleic Oleic acids
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Nitric acid (concentrated)
Pyridine
Hydrogen Sulfide
Benzene
Dichlorobenzene
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Xylene

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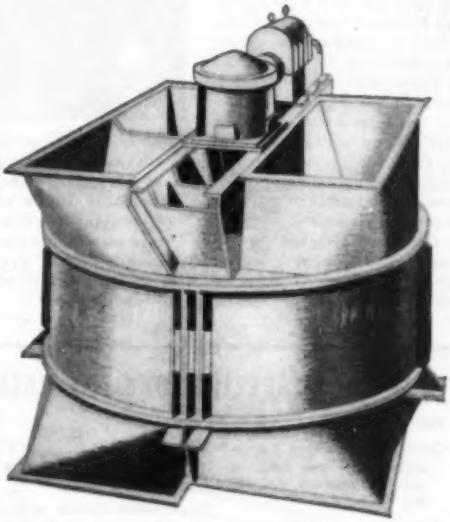
Raise the level of heat recovery

Save materials in plant design

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves the heat is transferred from the waste gases to the incoming cold air.



If you want to improve the combustion of low-grade fuels . . . raise the level of heat recovery . . . conserve critical materials in plant design . . . you or your consultants can make profitable use of Preheater experience. Let our specialists tell you more about the Ljungstrom Air Preheater, and the outstanding job it has done for hundreds of America's leading industries and public utilities, where the need for preheated air from 300F to approximately 1200F was part of their problem. Our engineers are ready to work with you in applying the Ljungstrom to your own heat recovery problem.

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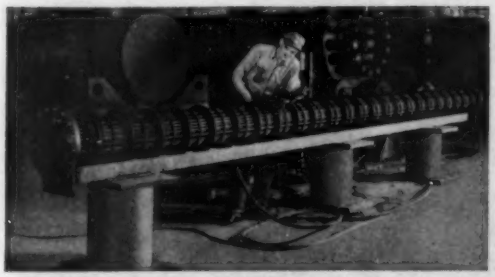
60 East 42nd Street, New York 17, N. Y.

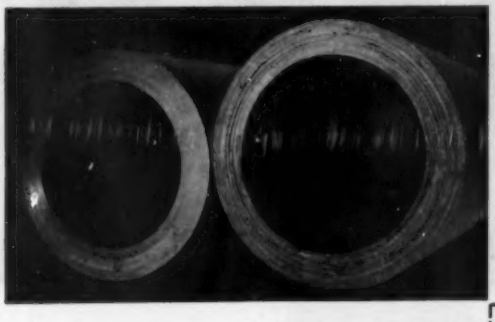
A.O.Smith Multi-Layer Heat Exchangers

MULTI-LAYER HeatExchanger for an ammonia plant. The shell, designed for 5150 psi working pressure, is 23 inches and 13¾ inches in diameter with wall thickness of 4¾ inches and 3 inches, respectively.

Meet the Challenge of High Pressure Specifications



Heat Exchanger tube bundle for the above is designed to take advantage of low differential operating conditions within an exchanger designed for 5150 psi chemical process.



Remarkable flexibility of design and manufacture makes A. O. Smith MULTI-LAYER Heat Exchangers adaptable to a wide range of high-pressure services.

MULTI-LAYER Heat Exchanger shells are built up from concentric layers of relatively thin steel plate progressively wrapped, tightened and welded together around an inner pressure-tight cylinder.

Wrapping tension and weld shrinkage develop desirable compression in the inner layers of the shell during manufacture. This results in more equalized loading of all portions of the heat exchanger wall under working pressure. Thus, the full calculated strength of the steel is more completely utilized.

Where corrosion is a problem, only the inner shell need be made of corrosion-resistant materials. The load-bearing portion of the vessel wall—since it is not in contact with corrodents—can be manufactured of more economical and readily weldable steel plate.

This feature, alone, frequently effects substantial savings over the cost of solid alloy construction and is especially advantageous during the current restrictions on use of certain alloy materials.

Call upon A. O. Smith for assistance on your heat exchanger problems. Write the nearest office or use the handy coupon.

End view of a MULTI-LAYER Heat Exchanger shell course showing how the wall is built up from concentric layers of thin steel plate. To the right: end view after wrapping is completed. To the left: end has been machined and scarfed, ready for welding to the next shell course or end closure.

A.O.Smith

77th ANNIVERSARY 1874 1951

VESSELS • HEAT EXCHANGERS

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International Division: Box 2023, Milwaukee 1

A. O. Smith Corporation
Dept. PR-851, Milwaukee 1, Wis.

Without obligation, send me bulletins and information on your MULTI-LAYER Heat Exchangers and their construction features.

Name_____

Address_____

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City_____

A Letter from

The Aquila Lubricating Oil Refinery in Trieste was the first engineering contract let under an E.C.A. loan. Legal problems — language difficulties — labor deficiencies were taken in stride and Badger completed the job three months ahead of schedule.

The refinery was designed and constructed by Badger and consists of a Propane Deasphalting Unit, a Furfural Plant, an MEK Dewaxing Plant and a Clay Contacting Unit. A full range of lubricating oils and finished waxes are manufactured with a maximum annual lube output of 32,000 tons.

Trieste . . .

„AQUILA"
Società per Azioni Tecnico - Industriale
Cap. Soc. L. 1.000.000.000 - Vers. L. 500.000.000
RAFFINERIA OLII MINERALI
TRIESTE

December 27, 1950

Mr. I.V. ReHill
E.B. Badger & Sons Co.
75 Pitts Street
Boston, Massachusetts

Dear Mr. ReHill,

We are bringing to an end the tests on the furfural plant and during the next few days we shall start operations.

From my office I can see the smoke of the stacks of the two heaters which are now drying out; it seems impossible to me that such a result could be obtained in this very short time. If I well remember, the first discussions on plant proportioning and our first meeting in Boston took place in August 1949.

On the occasion of the starting of the first luboil plant I wish to express you my sincerest congratulations for your wonderful way in organising this work; you must be really satisfied with the successful result obtained.

Yours sincerely,

T.L. de Pastrovich
Technical Director

Badger's broad experience in foreign work is available for projects of every size all over the world.

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A SUBSIDIARY OF STONE & WEBSTER, INC.
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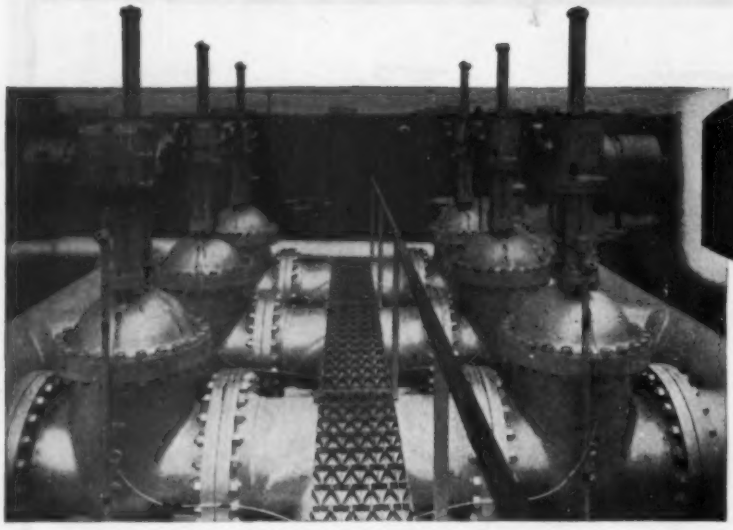
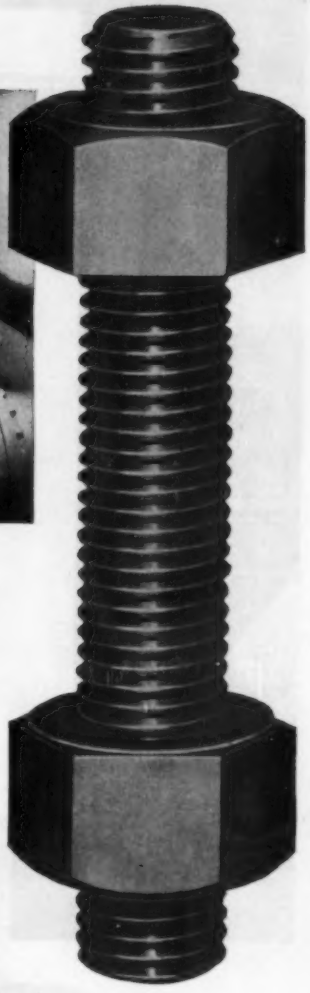
Process Engineers and Constructors for the Petroleum, Chemical and Petro-Chemical Industries

ON GUARD

AGAINST CORROSION ATTACK!





Republic Upson Alloy Steel Studs have the toughness to control heavy pressures. They have the heat-resistance to handle blistering high temperatures. And, *in addition*, they have the resistance to rust and corrosion that means long life in severe service.

These heavy-duty studs install fast—and when lines must be opened for purging and blowing down, nuts turn off as freely as they went on.

Next time studs need to be replaced, install Republic Upson Alloy Steel Studs for long, trouble-free service and lower maintenance costs. When ordering new equipment, specify these studs and make sure of dependable service right from the start.

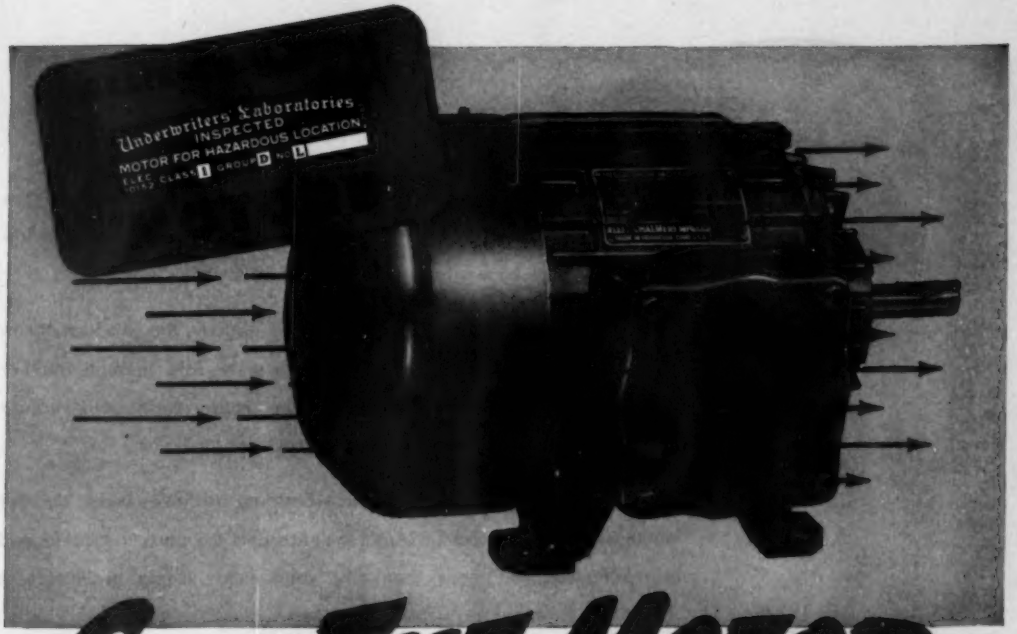
REPUBLIC STEEL CORPORATION
BOLT AND NUT DIVISION • CLEVELAND 13, OHIO
Export Department: Chrysler Building, New York 17, New York

REPUBLIC *Upson Quality* **BOLTS AND NUTS**

REPUBLIC STEEL

Made from Alloy Steel—from the furnaces of Republic, world's leading alloy steel producer.

Other Republic Products Include Machine, Tank and Carriage Bolts—Lag Screws, Cap Screws and Rivets



GET THE MOTOR that Cleans Itself

DROP MOTOR MAINTENANCE COSTS to a new low by reducing motor cleaning operations. And this new Allis-Chalmers Type APZZ explosion-proof motor makes maintenance costs lower than ever before on this type of motor.

Here's Why

Concealed air passages have been eliminated; dirt cannot build up to cause overheating. Cooling air is blown over the ribbed cast iron frame and bearing housings carrying dirt away with it. How about oily dirt that sticks? It can be wiped or blown off without stopping the motor.

Rigid Construction

The frame is rigid cast iron which not only has high inherent corrosion resistance, but also holds bearings in alignment. Bearings are pre-lubricated at the factory and should need no attention for years. Tapped holes with pipe plugs to permit regreasing and to provide grease relief are standard equipment.

Get All The Facts

The new Allis-Chalmers Type APZZ explosion-proof motor is built in all NEMA standard frame sizes from 224* to 505. Your A-C Authorized Dealer or District Office has complete information. Call today or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B6145. A-3319

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by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

TEXROPE — Belts in all sizes and sections, standard and *Vari-Pitch* sheaves, speed changers.

PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

Texrope and Vari-Pitch are Allis-Chalmers trademarks.

ALLIS-CHALMERS

*Similar design non-ventilated motors Type APKK, also available in frames 203 to 224 inclusive.

OR 15 years Tennessee Eastman has manufactured the most effective and efficient gum-inhibiting gasoline additives known to the refining industry.

While the name, TENAMENE, is new to the industry, the products themselves are not. Formerly these inhibitors were sold through another company and under that company's name. Today these additives are available directly from the basic manufacturer.

Whether you have been using these Eastman additives under another name or not, you'll find TENAMENE represents the peak in quality and performance. And more than this, you'll enjoy doing business with Tennessee Eastman.

We will be pleased to send you specifications, prices and samples. Write to Tennessee Eastman Company, a division of Eastman Kodak Company, Kingsport, Tennessee, or call our nearest sales representative.

Tenamene

EASTMAN GASOLINE ADDITIVES

TENAMENE 1 (N-butyl p-aminophenol) a gum inhibitor
TENAMENE 2 (di-sec-butyl p-phenylenediamine) a gum inhibitor
TENAMENE 60 (disalicylal propylene di-imine) a copper deactivator
Stocks of Tenamene are carried in Lodi, New Jersey; Houston; Los Angeles; San Francisco; and Kingsport, Tennessee.

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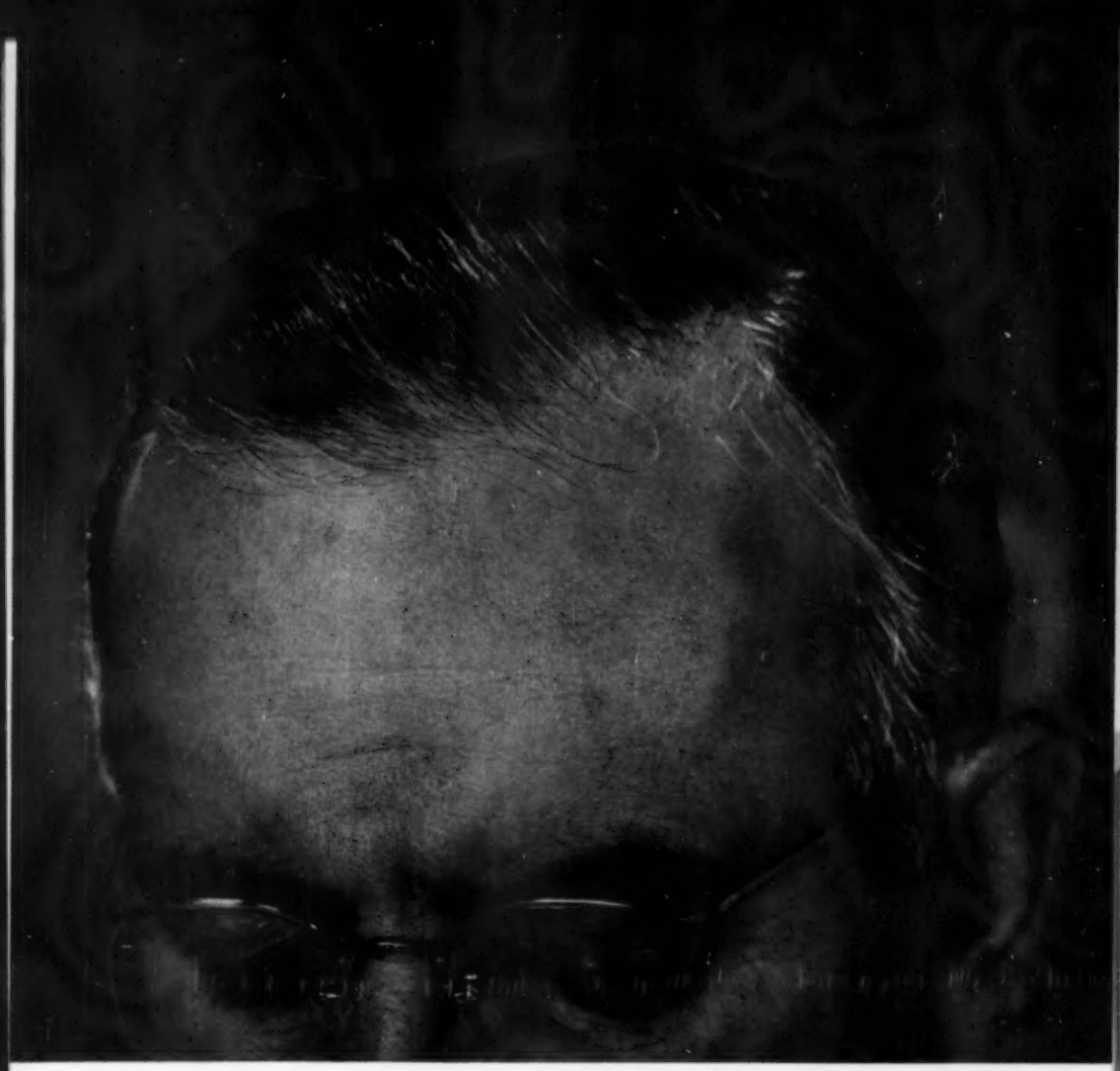


Research apparatus that cannot be duplicated

●

AMONG the many unusual pieces of apparatus which have been developed during the past quarter of a century at the Ethyl Laboratories, there is one that it would be extremely difficult—if not impossible—to duplicate.

That is our collection of human minds, each with the unique knowledge and experience needed to make progress in a highly specialized field. Only such

(*continued on next page*)

Research apparatus that cannot be duplicated

(continued from preceding page)

minds can fully grasp the complex, interrelated problems of fuel hydrocarbons, antiknock ingredients, lubricating oils, engines, and engine operating conditions. And only such minds can be of substantial help to the petroleum industry.

Ethyl has been building its research and service teams for over twenty-eight years. Many of our original people are still with us. They form the nucleus of an organization which now includes over four hundred fuel, antiknock and engine specialists, and one hundred and fifty representatives in the field. These people are not only individually capable, but they have worked and developed together as a team so that their collective value to Ethyl customers is far more than the net total of their individual capabilities.

Most important to you, this Ethyl team works for you every working hour, every working day of their lives.

ETHYL CORPORATION

NEW YORK 17, NEW YORK

*Experience**

is the most important ingredient in "Ethyl" antiknock fluid

*FARM SERVICE

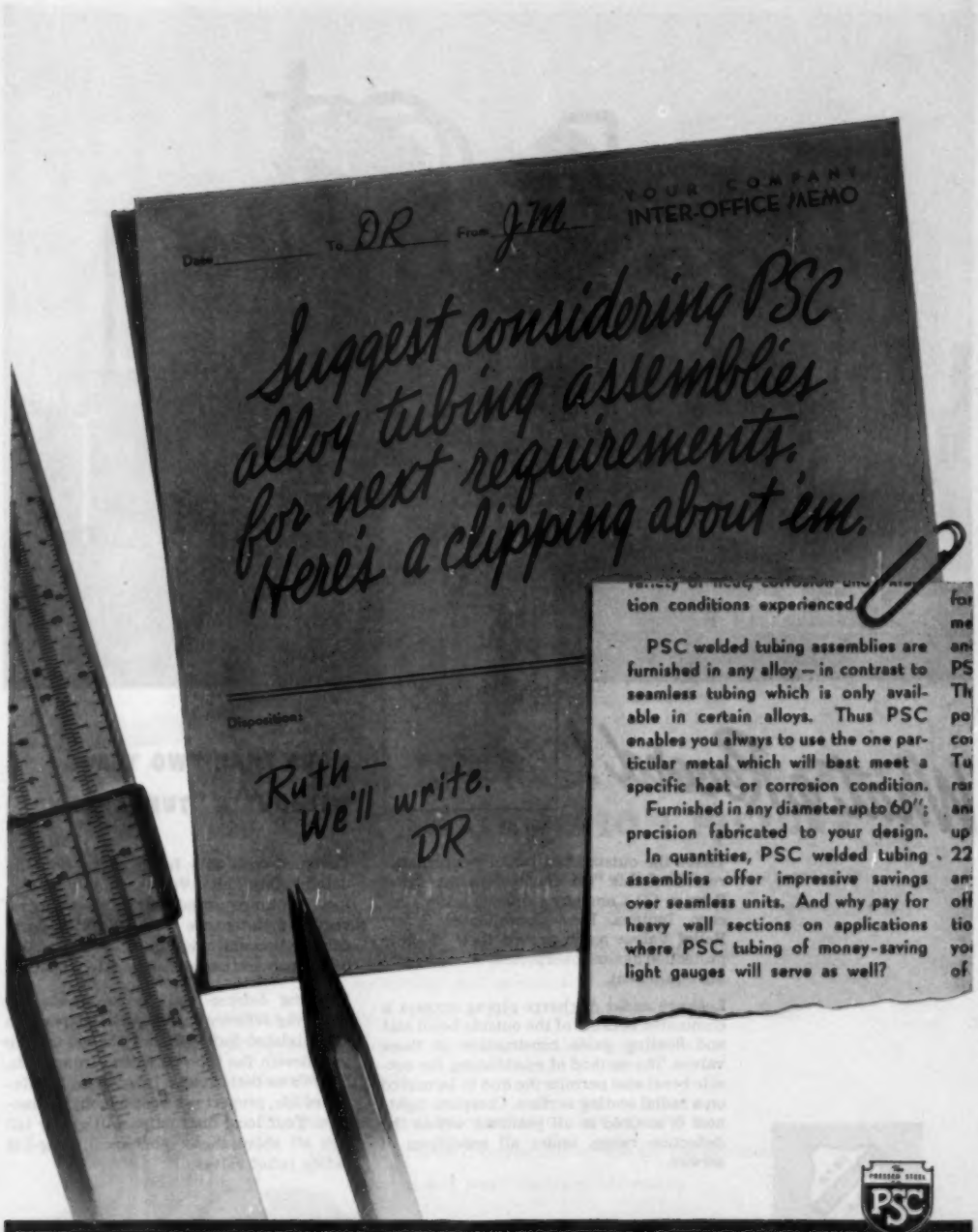
*FUEL RESEARCH

*ROAD RATINGS (Indoors)

*PREMIUM GASOLINE PROMOTION

*SAFETY SERVICE

*GASOLINE TESTING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Suggest considering PSC alloy tubing assemblies for next requirements. Here's a clipping about 'em.
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Furnished in any diameter up to 60"; precision fabricated to your design.
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Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

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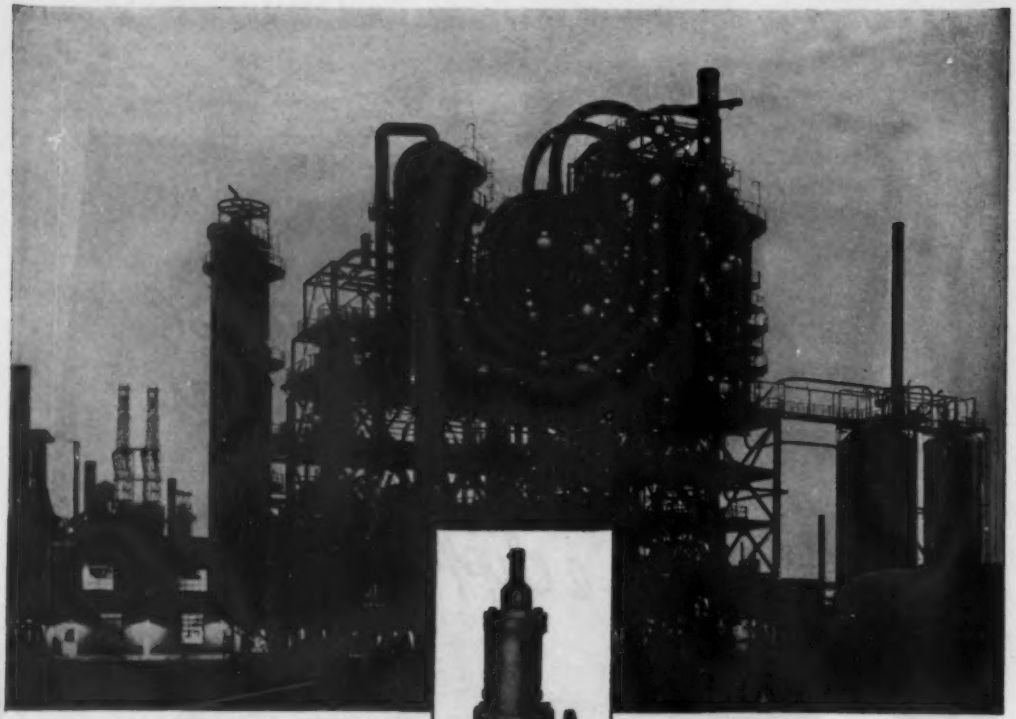


What a Record!

MORE THAN TWO YEARS WITHOUT A "TURNAROUND"!

That's the outstanding initial performance record of this "cat cracker" at the Cities Service Oil Company's refinery, East Chicago, Indiana. Here Consolidated Safety Relief Valves again proved their absolute protection against overpressures in processing equipment.

Leakage under discharge piping stresses is eliminated because of the outside bevel seat and floating guide construction of these valves. The method of establishing the outside bevel seat permits the disc to be moved on a radial seating surface. Complete tightness is assured in all positions within the deflection range, under all conditions of service.

Designed with 25% fewer parts, Consolidated Safety Relief Valves simplify servicing, minimize standardization problems, reduce maintenance costs. Working parts cannot become misaligned — continuous performance is assured at the rated capacity.

Growing defense and civilian needs are crowding refinery capacity. So—depend on Consolidated Safety Relief Valves to help you stretch the time between turnarounds. There's no better valve investment to safeguard life, property and continuous production. Your local distributor will gladly tell you all about these economical, long-life safety relief valves.

CONSOLIDATED SAFETY RELIEF VALVES

A product of **MANNING, MAXWELL & MOORE, INC.** TULSA, OKLAHOMA

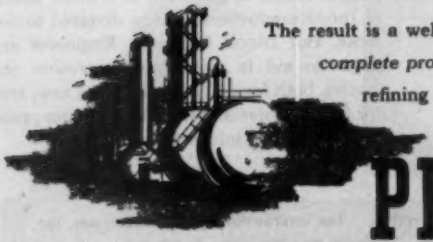
MAKERS OF 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' ELECTRICAL AND INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES. BUILDERS OF "SHAW-BOX" CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

THE BACKGROUND IS IMPORTANT IN THE CONSTRUCTION PICTURE

The name *Procon* is new . . . but the combined experience of the organization adds up to years of sound construction knowledge.

Behind every Procon job is an administrative group that has worked together on the installation and operation of all types of refinery processing equipment. And in the field, a highly competent staff applies its skill and experience to the construction of processing facilities.

The result is a well balanced team that provides a *complete process construction service* for the petroleum refining and petro-chemical industries.

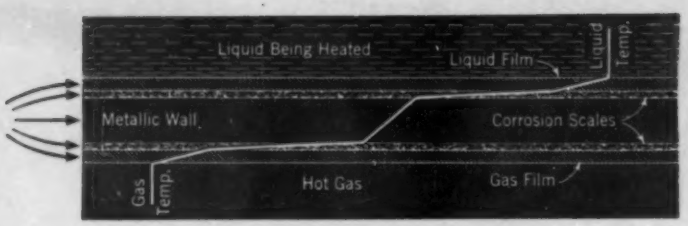


PROCON *Incorporated*

PROCESS CONSTRUCTION

75 EAST JACKSON BLVD., CHICAGO 4, ILLINOIS

Can you figure all the walls in heat exchange?

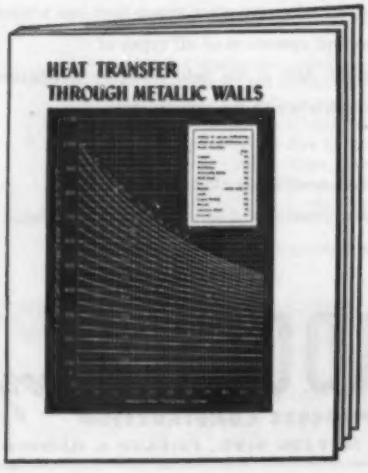


Add *two* unknowns to the heat transfer rate of a metal – and what do you get?

You get the problem that faces a designer trying to calculate the true performance of a proposed heat exchanger.

The rate of heat movement through a metal itself—of any thickness—is easily determined. But the effect of the gas or liquid films that will adjoin the metal wall is difficult to predict. And even more uncertain and more damaging, is the scale or oxide layer that forms on the metal surfaces.

The nature of the scale layer – its thickness, density, and chemical composition, is governed by conditions that vary in each case. But the insulating, or interfering, nature of the scale layer is tremendous.



Engineers are fast learning to hold scaling difficulties to a minimum—through the selection of metal. Nickel and high-Nickel alloys are among the preferred metals because of their resistance to scale formation.

Nickel forms a very thin, tough, oxide layer for self-protection. This layer is so thin it is often invisible. *But*, this thin layer prevents a buildup of more oxide, protects the metal against corrosive attack that would form other coatings.

The mechanical properties of Nickel alloys give high resistance to erosion or pitting from gas, steam, or liquid. Its strength and toughness also permit *thinner* walls, resulting in *faster* heat transfer.

INCO has issued a booklet—HEAT TRANSFER THROUGH METALLIC WALLS—that contains invaluable information on heat exchange performance of many metals. A copy of this bulletin will be sent free on request.

And if you have a specific heat transfer problem—the solution may be one of the INCO Nickel alloys. Right now, of course, much of Inco's production is being diverted to defense. But INCO's Corrosion Engineers are eager to aid in overcoming corrosion obstacles, both for defense operations now, and for future projects. Write us about your problem, giving full information.

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

PRESSURE TIGHT WITHOUT LUBRICATION

- NEW TEFLON-SEAL STUFFING BOX
- CUTS METER MAINTENANCE
- ELIMINATES LEAKS
- ELIMINATES SHAFT FREEZING

STANDARD IN 1800 PSI ORIFICE METERS

Teflon-Seal Stuffing Boxes have been operating for more than two years without servicing in thousands of orifice meter installations! Applications such as sour gas, wet gas, caustic solutions — almost every conceivable service — have failed to impair meter operation. Maintenance problems are drastically reduced or eliminated!

The Teflon-Seal bearing is pressure-sealing around a precision made, centerless-ground Monel metal shaft, *without grease and with minimum friction.* All other stuffing box parts are corrosion resistant stainless steel. The Teflon-Seal Stuffing Box is suitable for ambient meter temperatures to 150°F. and working pressures to 1800 psi. Units are adaptable to older types of orifice meters now in service.

Here is another example of American Meter Company's policy of constant product improvement to uphold a century-old tradition of "*Sustained Accuracy at Lower Cost.*"

See our display, booth 101-5, Sixth National Instrument Exhibit, Sam Houston Coliseum, Houston, Texas, September 10-14.

PROPERTIES OF TEFLON

Teflon (polytetrafluoroethylene) is a synthetic polymer with the following properties: low coefficient of friction — zero water absorption — high impact strength — toughness — form stability — and exceptional chemical inertness. It retains strength at temperatures from —100°F. to 550°F. and does not stick or "weld" to other materials. It resists the attack of all known solvents except molten alkali metals, with no change in weight or properties.

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AMERICAN METER COMPANY

News for the Southwest

ALCO Exchangers, now built in Texas

faster service, greater convenience, more time saved

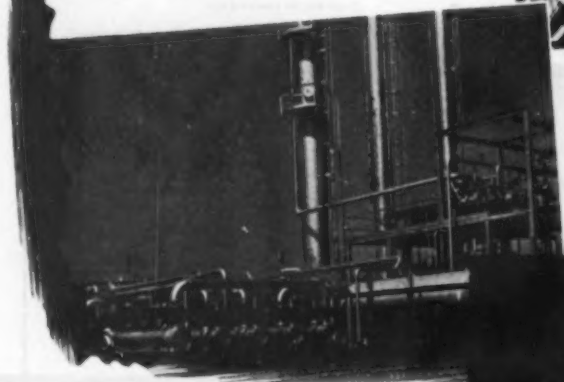
At the **Beaumont Iron Works,** in the heart of the Southwest, engineers and designers who know oil, and understand its requirements, are now building ALCO heat exchangers. To the quality and dependability of these exchangers is now added the advantages of a strategic location—savings in time and greater convenience.

Put these extra values to work for you by calling in the ALCO-BIW representative when you need heat exchangers. The Beaumont Iron Works Company—Beaumont, Texas—is a subsidiary of the American Locomotive Company.

SPECIAL EXCHANGER EQUIPMENT. For years ALCO has successfully handled the problems connected with large or special heat exchanger equipment.

CAREFUL CONSTRUCTION. ALCO's long years of experience are your guarantee of quality that's built into every one of these heat exchangers.

PROVEN PERFORMANCE. In numerous installations like this large Southwestern natural gasoline plant ALCO exchangers prove their mettle in the toughest test of all—actual operation in the field.



***In step with tomorrow*—ALCO AIRCOOLERS, Heat Exchangers, Evaporators, Feedwater Heaters, Pressure Vessels, Pipe**

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ALCO Products Division

AMERICAN LOCOMOTIVE COMPANY

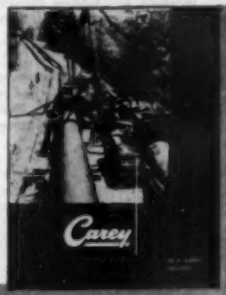
If YOUR JOB INVOLVES

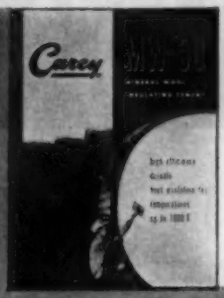
- oil or gas pipelines
- processing operations
- refinery construction or maintenance...

You need this helpful literature!

Asbestos pipeline felt data book...

a discussion of protective coatings for pipelines by a competent corrosion engineer. Covers the fundamentals of low cost, dependable pipeline protection. Timely, informative, fully illustrated.



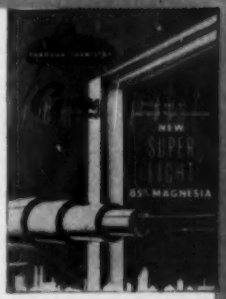


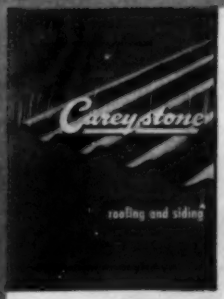
Carey MW-50 data book...

describes the most modern method for insulating all types of heated equipment having temperature ranges up to 1600°F., and gives details for applying insulation on irregular or hard-to-reach surfaces.

Super-Light 85% magnesia data book...

description, specifications and recommended uses for a new, improved insulation in precision-sized monolithic blocks, molded pipe coverings and cements.





Careystone corrugated asbestos-cement roofing and siding data book...

technical data, application details and specifications covering the economical use of Careystone asbestos-cement for all types of buildings.

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The Philip Carey Mfg. Co.
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Gentlemen: Please send me without charge the Carey Data Books on ☐ PipelineFelt ☐ Super-Light 85% Magnesia Insulation ☐ MW-50 Cement ☐ Careystone Asbestos-Cement Roofing and Siding. Place check mark in box before Data Books wanted.)

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This close-up clearly shows the ribs or corrugations which add strength to Childers Jacketing and also make it form more easily around lines. Aluminum strapping and seals are a quick, inexpensive way to attach the jacketing. They can be used without any special tools and take no special training for the installers.

Does long lasting aluminum cost too much for covering your insulated lines? Not when you specify this new type weatherproof jacketing. It has been specially developed to cost little more than ordinary temporary jacketing materials.

New Low-Cost Jacketing Cuts Maintenance on Insulated Lines

AT LAST an aluminum jacket has been "engineered" especially to protect outdoor lines in refineries and chemical plants. It is the first "permanent-type" jacketing that offers both low initial cost and low application cost.

After two years of tests and major installations at 431 outdoor locations in refineries, chemical plants and power plants, the Childers Manufacturing Co. of Houston has rung up an impressive cost-cutting record with their Childers Aluminum Jacketing.

Secret behind this low cost is the thin aluminum sheet—.006" thick—which is the weather-protecting sheath of the jacketing. It is ribbed (as pictures show) for extra strength and to facilitate forming around the line. This aluminum has proved thick enough to resist weathering and usual abrasion, but costs much less than heavier aluminum sheets.

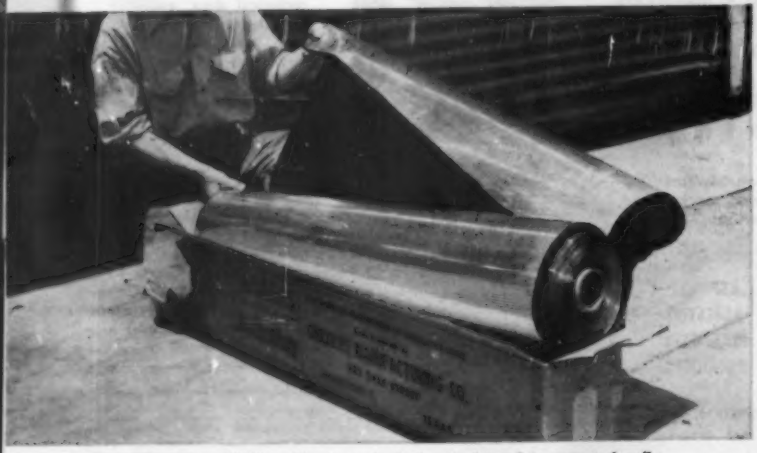
Easy application of this Childers Jacketing cuts labor bills drastically. It comes from the factory in easy-to-handle rolls that are four feet wide and either 100 feet or 200 feet long. It is light and flexible to handle as the men put it on the line. No roll forming required as with heavy, un-crimped material. It can be cut off and attached just the same as the old-fashioned tar-paper that was sometimes used for jacketing.

You can attach Childers Jacketing around your insulated lines by one of several easy methods. The use of aluminum strapping and seals is probably the best. Sheet metal screws or Minnesota Mining's No. 471 tape can also be used. The Childers jacketing can be removed and re-used.

A moisture barrier is attached to the back of the jacketing to give positive protection for the aluminum when it is used with alkaline insulating materials.

No painting, no rust-proofing, little maintenance — that's the advantage of aluminum!

Hundreds of design engineers and maintenance engineers have agreed they save money for their firms and trouble for themselves by changing their jacketing specs to Childers 100%. That should make it worth your testing too—and a test roll costs only $40.00 for 400 sq. ft. (with moisture barrier attached—price for 800 sq. ft. without moisture barrier $62.00). That's a good investment in any plant.



This is how Childers Aluminum Jacketing is shipped in easy-to-handle rolls. It is quite flexible, yet stands up under severe weathering.

FOR FULL INFORMATION write Childers Manufacturing Co., Dept. PR-6, 625 Yale St., Houston 7, Tex., for complete literature. Childers has engineering representatives in principal cities to work with you on specific problems.

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again... Esso Pioneers with Advanced Foxboro Controls!

In the new MEK Solvent Dewaxing Unit completed May 15, 1950, Esso-Standard Oil Company at Bayonne, N. J., cut costs and assured greater controllability of the entire process by means of the Foxboro Model 40 Controllers at many critical points. In addition, an economical feedback intercooling system, and a notably improved sequence control for the refrigeration compressors, were both developed around the Model 40 Controller.

The new Esso MEK installation typifies the many improved control systems now made possible by the inherent stability of Foxboro M-40 control action. M-40 Controllers give you the most advanced developments in the field of pneumatic instrument design. Available for temperature, pressure, flow, level and other applications. Write for full details. **The Foxboro Company, 748 Neponset Ave., Foxboro, Mass., U. S. A.**

In the new Esso-Standard MEK Solvent Dewaxing Plant at Bayonne, N. J., (built by E. B. Badger & Sons Co.), 30 Foxboro M-40 Controllers give dependable automatic control at critical process points.

Panel containing M-40 Controller and sequencing equipment for three compressors — engineered by Foxboro.

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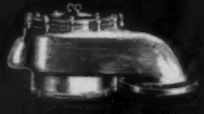
Semi-Automatic Tank Gauge and Sampling Lock, Fig. ST-3320 "DLB." Can be used for sampling and temperature thiefing. It is mounted here on S&J's Quick Opening Gate Valve, Fig. TT-135 which can be opened or closed with only half the number of turns required by other valves.

Pilot Operated Safety Relief Valve, Fig. ST-2500. Designed to protect tanks from excessive internal pressure. One pilot valve can serve one, two, or more main valves to meet high venting requirements. Main valve pallet is seated under pressure to moment of venting. This valve requires no great excess pressure for full venting capacity.



Vacuum Breather Valve, Fig. ST-1926. Designed to meet the unusual vacuum breathing requirements of pressure storage tanks, and to withstand high internal pressures when not in operation under a vacuum. This valve is automatically self draining, and utilizes a hinge type pallet.

High Pressure Automatic Tank Gauge, Fig. ST-400, will consistently and accurately measure product depths. Features new Safety Closure to protect extra thick Safety Glass. Gauge greatly reduces time required to measure tank contents accurately, because it can be installed at eye level height.

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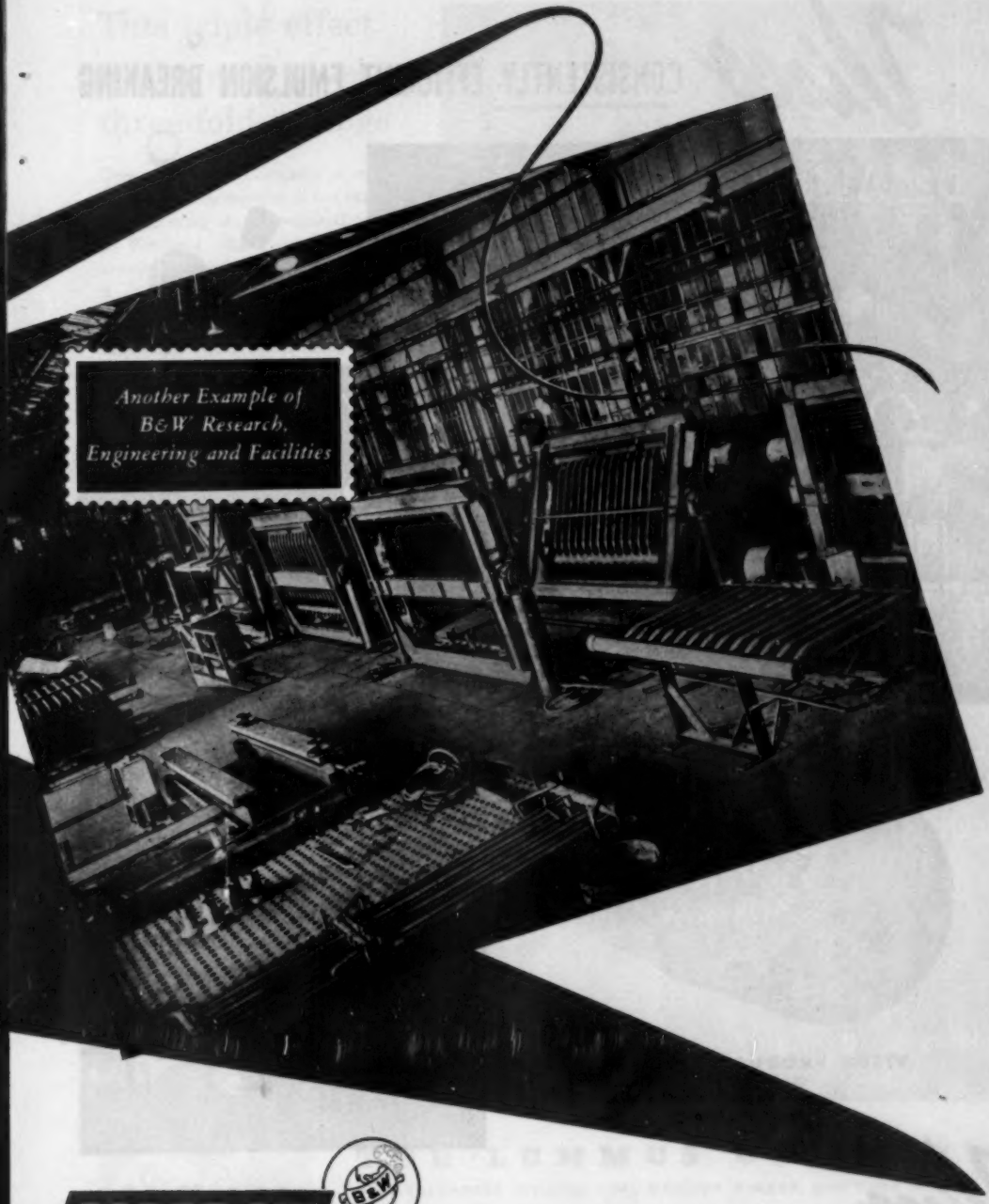

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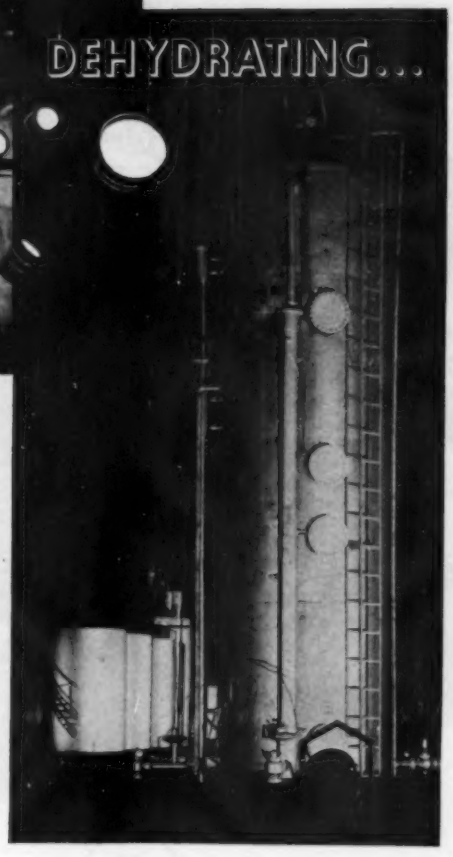

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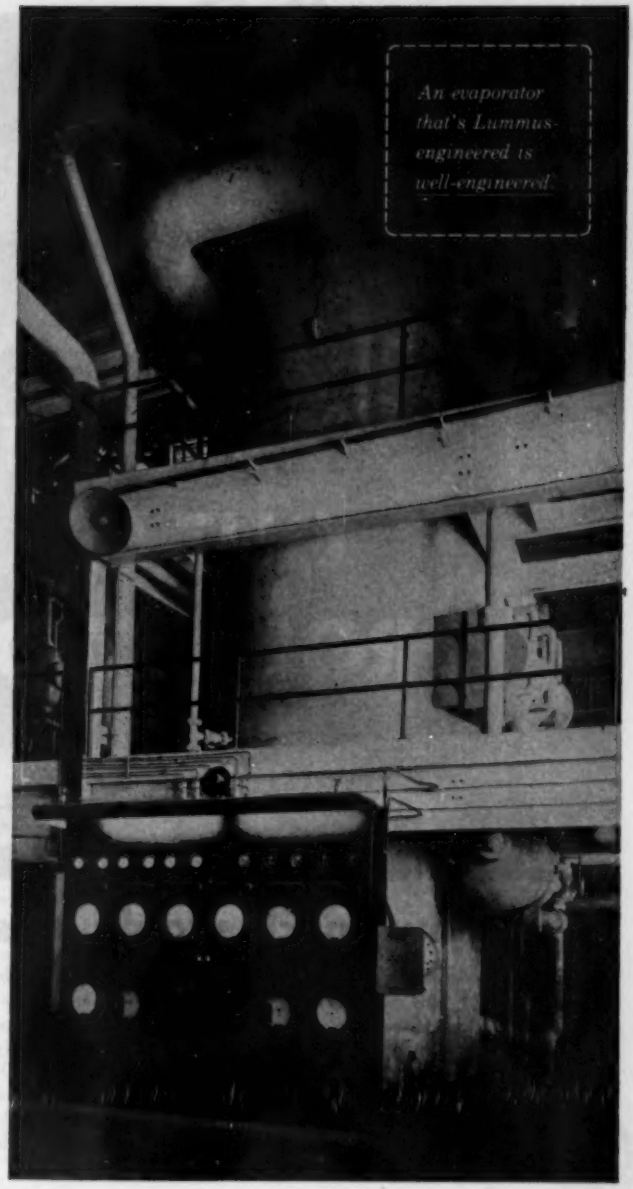
This triple effect evaporator gives three-fold savings

General Electric Company is recording unusual economies in the amount of generating steam required to run its Pittsfield, Mass. power plant. A heavy contributor to these savings is the Lummus-designed-and-built evaporator pictured here.

This triple effect vessel really wrings maximum efficiency out of exhaust steam. Employing three effects (or stages) of evaporation—all built into one shell—the unit produces about 140 gpm of high purity distilled water, at a consumption of approximately 20,000 lb./hr. of 1.5 psig steam and 100 gpm of city water. With a sharp eye to practical aspects, Lummus designed the unit so that hot "liquor" is dumped from one effect to the other, thus minimizing heat make-up. And when the third phase is completed, all but 4 gpm of original feed water is vaporized.

The vertical, three-compartment unit is 30'6" high x 10'6" dia. Each effect contains a removable tube bundle of 956 tubes, ¾" O.D. x 9'0" long. Other components completing this all-Lummus installation are: a 1500 sq. ft. surface condenser, a feed water pre-heater, and a two-stage steam jet air ejector complete with a single inter-after condenser.

Three years in service, the Pittsfield job shows a degree of performance that's not at all unusual when you're talking about Lummus equipment. That's why it will pay you to give *your* next heat transfer job to Lummus.



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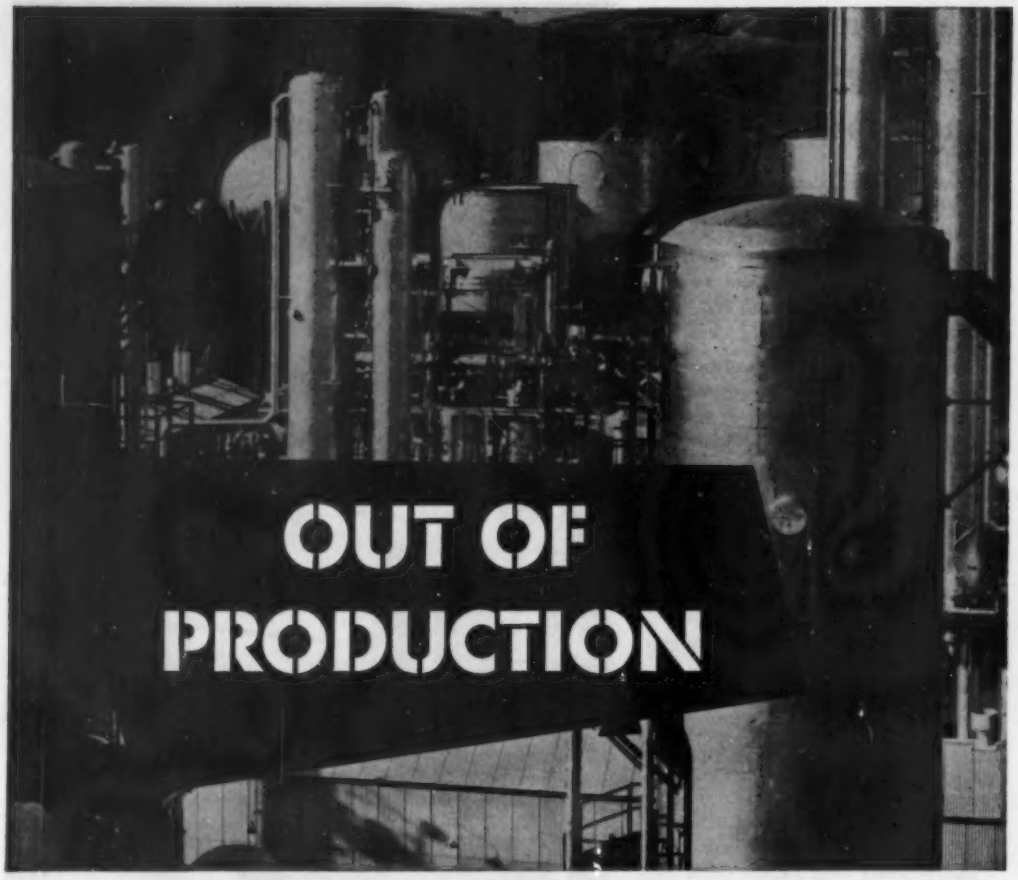

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WETth where it doesn't belong can be ruinous. To control WETth (unwanted moisture in air or gases), to DRY air and gases, don't rely on homemade systems. DRY with a Lectrodryer*—get the full benefit of Lectrodryer's 20 years of experience in engineering, building and installing DRYing systems.

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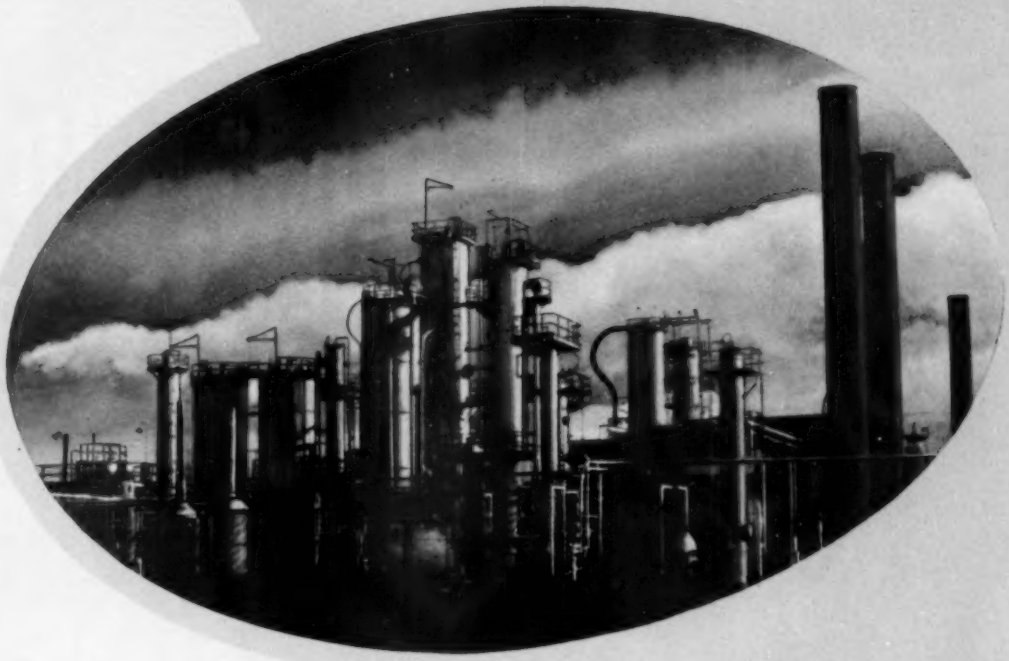

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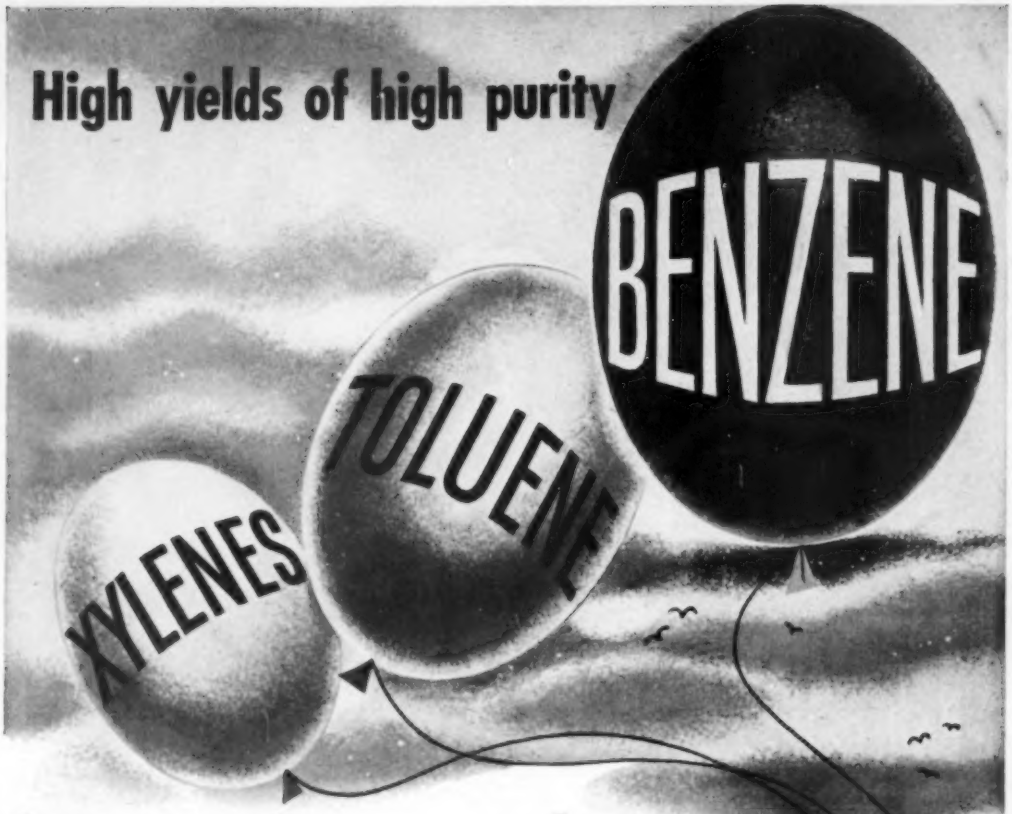

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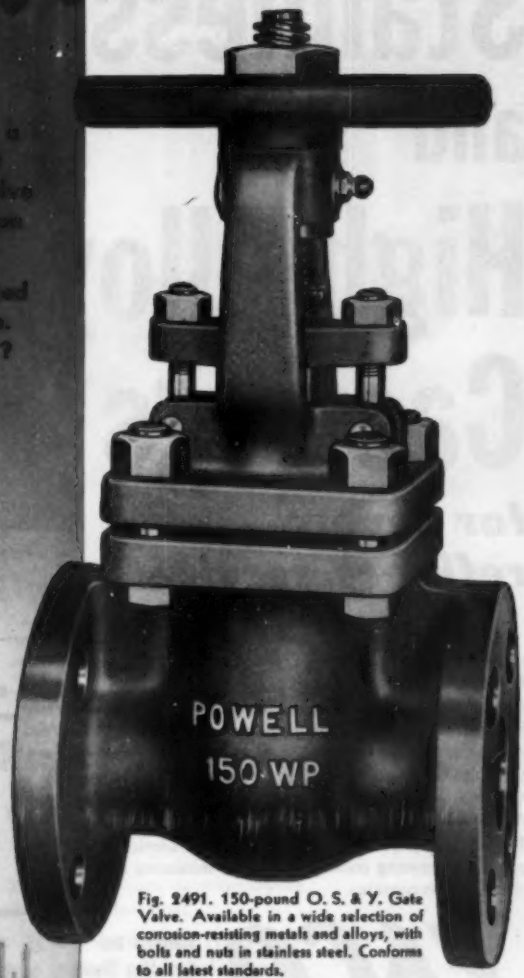

Fig. 2491. 150-pound O. S. & Y. Gate Valve. Available in a wide selection of corrosion-resisting metals and alloys, with bolts and nuts in stainless steel. Conforms to all latest standards.

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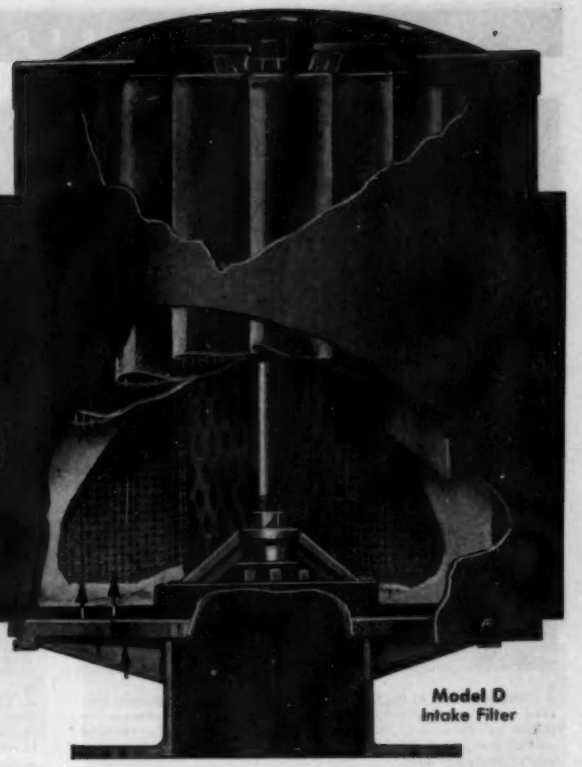

Model D
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This fact can mean the difference between *full* and *seriously reduced* output . . . between *frequent repairs* due to intake of abrasive, clogging dust and *no repairs*.

All Staynew Intake Filters are Dry-type — no moving parts, no reservoirs, no liquids. Air velocity is not critical, temperature extremes have no effect. As dust accumulates on the medium, filtering efficiency increases — *yet tests prove that resistance may reach less than 2.75" water after thousands of hours of operation.* Radial Fin design of insert and all-wool felt medium provide unsurpassed protection . . . virtually 100%. More than 600,000 Staynew Intake Filters have been placed in service. *A fine engine or compressor deserves a fine filter.* Specify Staynews for more HP or CFM at lowest possible cost.

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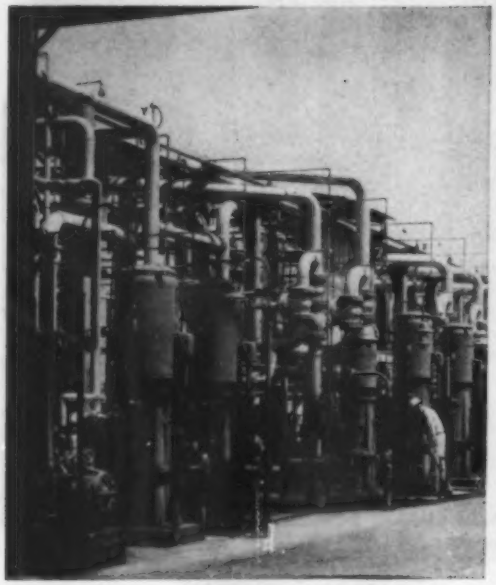
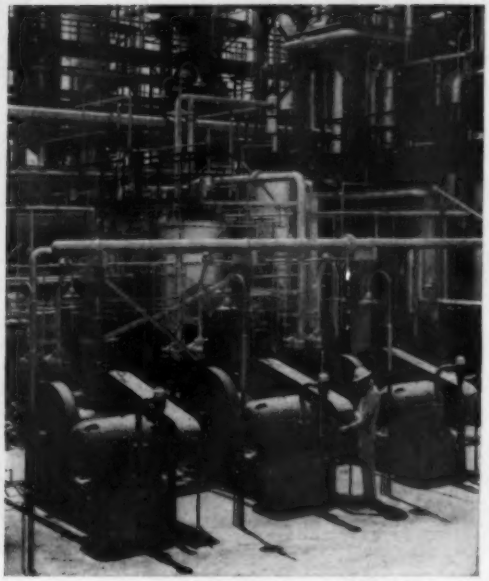
FILTERS FOR: ENGINES • COMPRESSORS • PIPE LINES (AIR, GAS, LIQUID) • VENTILATION

A PHOTO-REPORT ON MODERN



1 **ONE FEATURE** of the Oleum refinery is its Duo-Sol extraction unit, used in the manufacture of lubricants. Pumps used in this process are driven by these G-E 2300-volt and 220/440-volt totally enclosed vertical motors rated from 20 hp. to 125 hp. Capacity of the unit is 6000 barrels per day.



2 **COMPRESSOR UNITS** in the Duo-Sol process section are driven by these three G-E 100-hp 2300-volt motors. Because of their corrosion-resistant totally enclosed fan-cooled construction, they are well suited to refinery conditions, regardless of the type of acids, alkalis or solvents encountered.

Co-ordinated electrical system helps keep lube-plant yield high!

Engineered G-E drives and power distribution equipment assure needed reliability at Union Oil Company's refinery in Oleum, California.

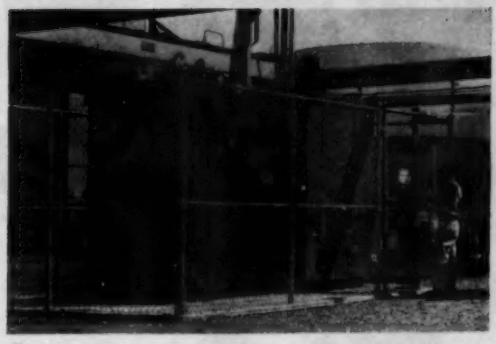
From 75,000 barrels per day of crude, Union Oil's Oleum refinery processes all types of lubricating oils, plus gasoline, diesel oil, greases, refined wax, and other products. To maintain this diversified output, General Electric power-distribution and drive equipment provides the dependable electric power needed. Co-ordinated from start to finish, this installation is further proof that General Electric can meet all *your* refinery's electrical needs. Ask your G-E representative to give you the facts. General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC

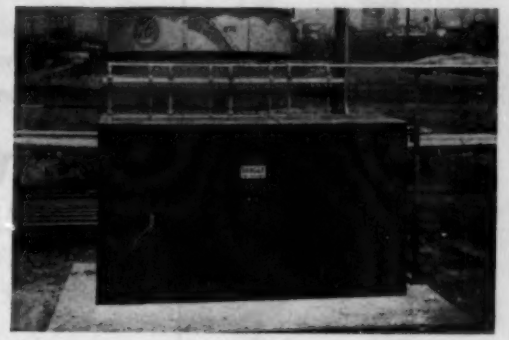
661-27

3 PROCESS CONTROL for the Duo-Sol extraction unit is centralized in this pressurized and vapor-proof building to permit the use of standard non-explosion-proof equipment. Shown here are G-E limitamp motor-starters rated up to 350 hp and a Trumbull switchboard for controlling small motors.

4 PROTECTION against complete plant shutdown is part of the job for this incoming line G-E metal-clad switchgear assembly with dual feeders.



5 FOR LOW-VOLTAGE NEEDS, this G-E outdoor-type 500-kva load-center substation steps down 2400-volt power to 480 volts close to where it's needed, cutting voltage drop and power losses. Complete and co-ordinated, these G-E metal-enclosed units are factory-built for quick installation.



6 CONTROL OF HIGH-VOLTAGE MOTOR and short circuit protection are both provided by this G-E outdoor-type limitamp assembly, serving a transfer pump house. Current-limiting fuses in limitamp controllers cut off current fast when a short occurs, protecting equipment against extensive damage.

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Gear reduction ratios up to 432 to 1

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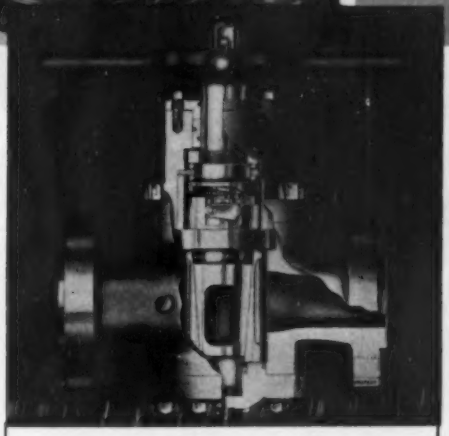
NON-LUBRICATED
TWIN SEAL
VALVES



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- ✓ Shuts off vapor-tight.
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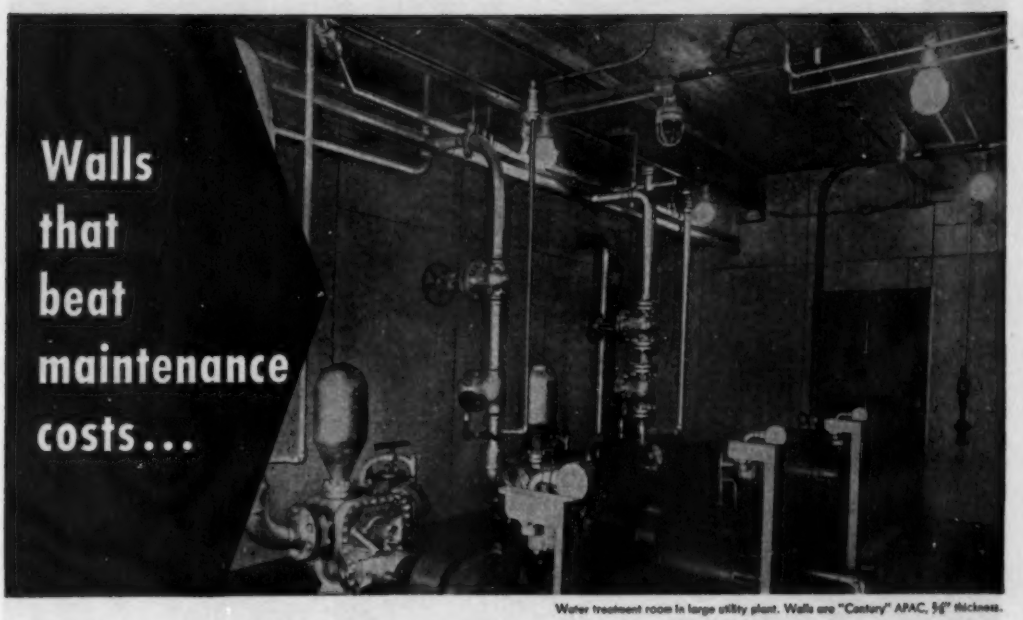

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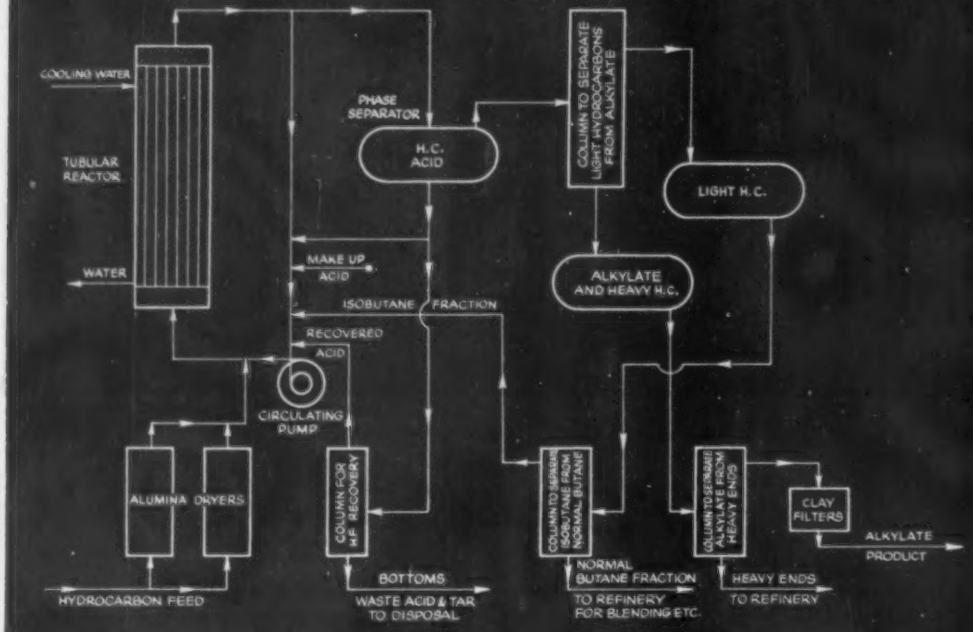
For ANHYDROUS HF

Depend on GENERAL CHEMICAL



Ever abreast of the needs of the Petroleum Industry, General Chemical is geared to serve today's increasing demand for Anhydrous Hydrofluoric Acid in production of blending components for aviation fuels. Our extensive plant capacity developed during World War II is strategically located . . . and our knowledge of Hydrofluoric Acid and its handling reaches back half a century.

Whether you now use Anhydrous HF to produce alkylate in the older vertical reactor—or anticipate its use in the newer horizontal reactors—discuss your needs with General Chemical first. For further information, consult our nearest office listed below.

Helpful Data on Anhydrous HF

General Chemical's 24-page Technical Service Bulletin No. 30-A on Hydrofluoric Acid, Aqueous and Anhydrous, contains data on physical and chemical properties, solubilities, corrosion data, safety and precautions, etc. Also a bibliography on properties and uses in organic reactions.

For your free copy, please write on business letterhead or phone any company office.

GENERAL CHEMICAL DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.

Offices: Albany • Atlanta • Baltimore • Birmingham • Boston • Bridgeport Buffalo • Charlotte • Chicago • Cleveland • Denver • Detroit Greenville (Miss.) • Houston • Jacksonville • Kalamazoo • Los Angeles Minneapolis • New York • Philadelphia • Pittsburgh • Providence St. Louis • San Francisco • Seattle • Yakima (Wash.)

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Montreal • Toronto • Vancouver

BASIC CHEMICALS
FOR AMERICAN INDUSTRY ©

a Sweet Performing Valve

PROCESSING TANKS FOR CHERRIES AND SYRUP AT DAGGETT CHOCOLATE COMPANY, CAMBRIDGE, MASS.

These tanks at the Daggett Chocolate Company process thousands of gallons of syrup and cherries. The syrup and cherries are used to make Daggett candies and are also supplied to ice cream manufacturers and bakeries. Rockwood Ball Valves help keep these tanks in operation by giving longer and better trouble-free service. These Valves are constantly in use and have been on the lines for over 2 years — and during that time required *no maintenance*.

Floors are kept clean because when Rockwood Ball Valves are closed, they close tight and prevent syrup from dripping. Other makes of valves leaked as sugar would get into the valve slot and prevent a tight seal.

Rockwood Ball Valves are also used to draw-off corn syrup and on draw-off lines on cooking kettles.

Remember — every Rockwood Valve is designed and built to outlast any other valve on the market. See your distributor — see for yourself that Rockwood Ball Valves have the best engineering features your money can buy. Look for these outstanding features when you buy your valves — leak proof service, full *round* flow, easy operation, no maintenance.

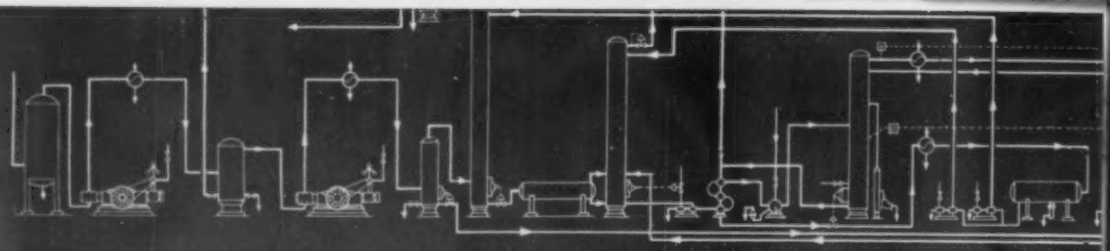
Rockwood Ball Valves are recommended for 300 p.s.i. working pressure. Thousands of Rockwood Ball Valves are in service in oil refineries, food, paper, textile, chemical and rubber plants, etc. Write today for prices and sizes.

Distributors in all principal cities.

ROCKWOOD

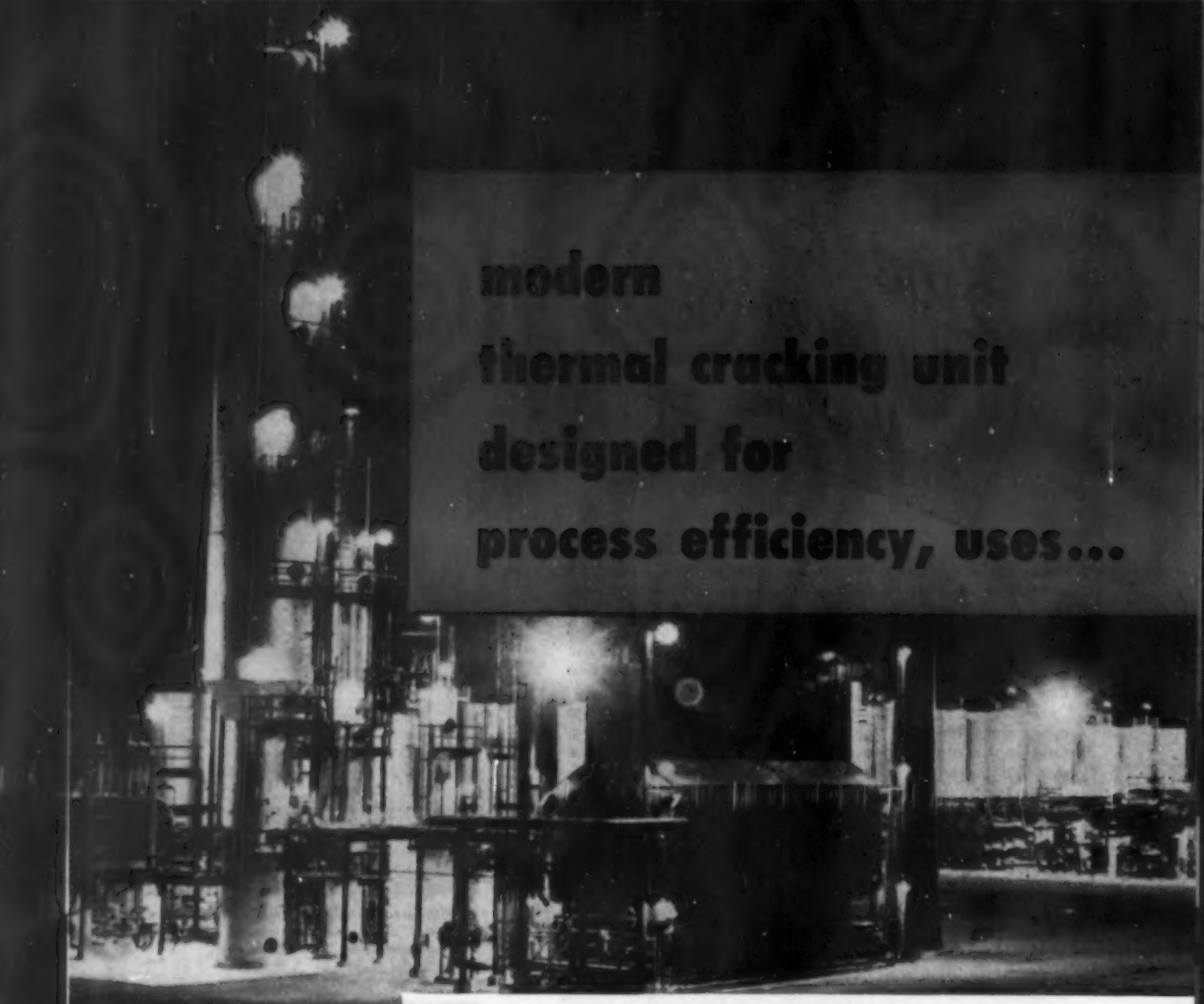
2" Rockwood Ball Valve on corn syrup draw-off line. Tight seal of floating ball against synthetic seat prevents syrup from dripping on floor.

ROCKWOOD
SPRINKLER COMPANY
102 HARLOW STREET
WORCESTER 5, MASS.

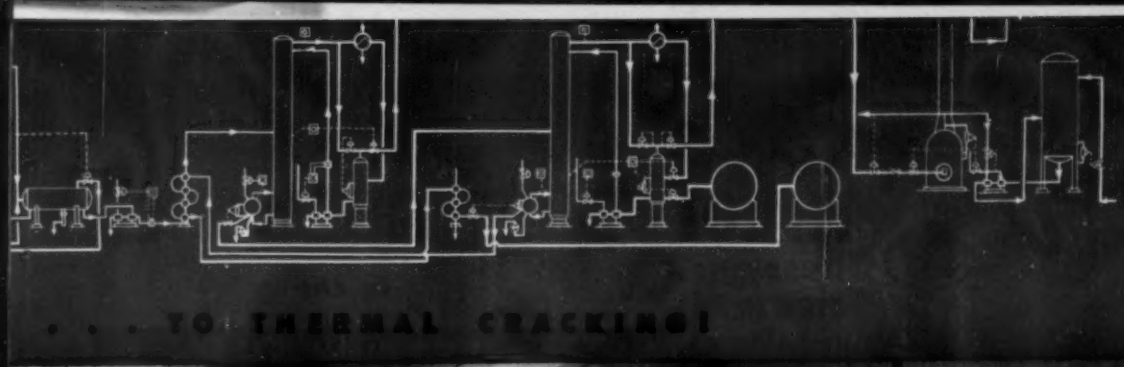


BROWN INSTRUMENTATION*
IS THE MODERN APPROACH . . .

modern thermal cracking unit designed for process efficiency, uses...



* **BROWN INSTRUMENTATION** . . . is patterned to the exact requirements of individual plants and processes . . . is the result of engineering and application know-how, with one responsibility from sensing elements to control valves . . . is backed by a nation-wide field engineering and service organization.



. . . TO THERMAL CRACKING!

BROWN INSTRUMENTS AND CONTROLS

As a result of extensive modernization, Standard Oil Company of California's Bakersfield refinery has been able to increase by 50% the amount of crude oil processed daily.

New facilities at the plant reflect the trend toward high temperature cracking . . . to increase gasoline yields and meet the demand for high octane fuel.

Engineered and constructed by C. F. Braun & Co., the Bakersfield refinery includes Brown Instrumentation for regulating critical process variables on the crude and thermal cracking units. The result is a new high in operating ease and process efficiency.

When looking for recording and controlling instruments for your thermal cracking units, or *any refining operation—consider first:*

**The Brown know-how developed through many years of application experience in the industry.*

**The completeness of the Brown modern approach —recorders, controllers, panelboards (including Graphic Panel) valves, and all accessories.*

Call in our local engineering representative for a detailed discussion of your process control requirements . . . he is as near as your phone.

Minneapolis-Honeywell Regulator Co., *Industrial Division*, 4498 Wayne Avenue, Philadelphia 44, Pa.

MINNEAPOLIS **Honeywell**

Brown Instruments

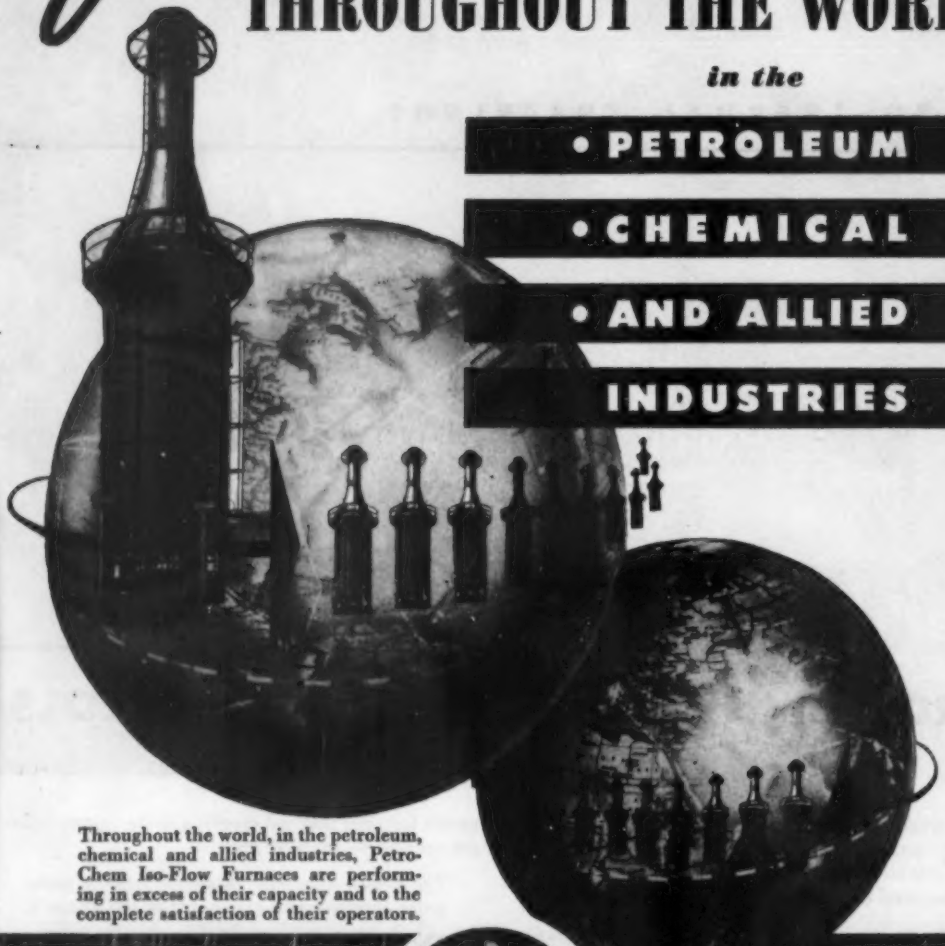
PETRO-CHEM ISO-FLOW FURNACES

favored

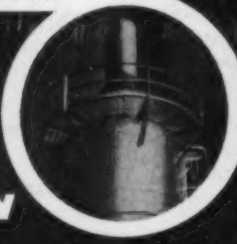
THROUGHOUT THE WORLD

in the

- PETROLEUM
- CHEMICAL
- AND ALLIED
- INDUSTRIES



Throughout the world, in the petroleum, chemical and allied industries, Petro-Chem Iso-Flow Furnaces are performing in excess of their capacity and to the complete satisfaction of their operators.



PETRO-CHEM

ISO-FLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC., 120 EAST 41ST STREET, NEW YORK 17, N.Y.

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Bethlehem Supply, Tulsa and Houston · Flagg, Brackett & Durgin, Boston · D. D. Foster, Pittsburgh

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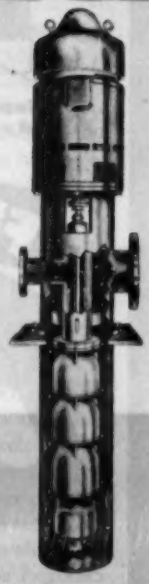
Boiling point temperatures and limited NPSH pose no problem for these VMT pumps!

WHEN PUMPING FLUIDS at boiling point temperatures, the problem of sufficient net positive suction head often requires expensive installation to raise the vessel from which the pump would draw or to excavate a pit to lower the pump.

This is eliminated with the BJ "VMT" pump because the vertical multi-stage pumping unit is mounted in a barrel from which it takes a suction. The base of the pump is at ground level while the length of the barrel is determined by the NPSH requirement.

The "VMT" pumps (shown above) serving as boosters from gasoline tank farm to main line stations are just one of the many successful applications for refineries, pipe lines, fueling stations, power plants, and process industries. For more detailed information on how the "VMT" may solve your pumping problem, call your local BJ sales office or send the coupon below.



FILE FACTS:

- Capacities to 5000 gpm. Heads to 250 psi. Temperatures from sub-zero to 750° F.
- Handles corrosive or non-corrosive liquids
- Radial forces balanced at all speeds
- Adjustable coupling for easy, accurate impeller setting

Also available in the smaller "VLT" model (capacities to 110 gpm). Provides the same basic construction and installation advantages as the "VMT," yet is priced for general purpose application.

Byron Jackson Co.

Since 1872

P. O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

OFFICES IN PRINCIPAL CITIES

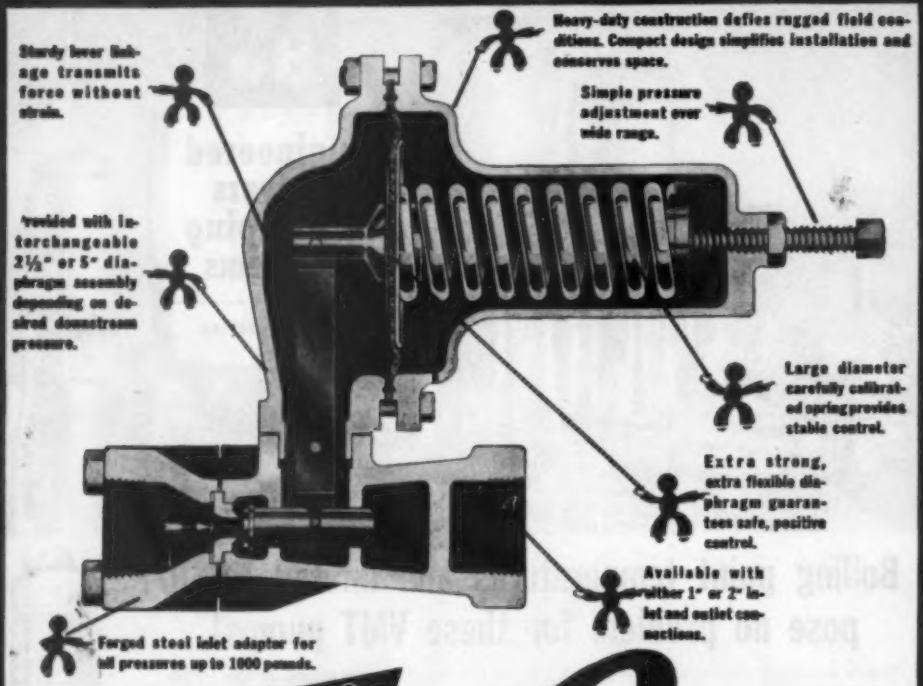
BJ Pump Division, Dept. 27
Please send me Bulletin No. 51-6600 on your VMT pump.

NAME_____

FIRM_____

ADDRESS_____

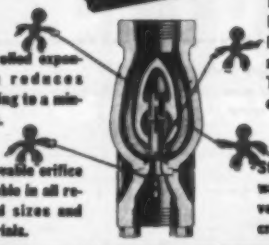
CITY_____ ZONE____ STATE____


Heavy-duty construction defies rugged field conditions. Compact design simplifies installation and conserves space.
Sturdy lever linkage transmits force without strain.
Simple pressure adjustment over wide range.
Provided with interchangeable 2½" or 5" diaphragm assembly depending on desired downstream pressure.
Large diameter carefully calibrated spring provides stable control.
Extra strong, extra flexible diaphragm guarantees safe, positive control.
Available with either 1" or 2" inlet and outlet connections.
Forged steel inlet adapter for all pressures up to 1000 pounds.

FISHER®

Big Joe

FIELD REGULATOR TYPE 630


Controlled expansion reduces freezing to a minimum.
Removable orifice available in all required sizes and materials.
Removable disc holder assembly. Disc of synthetic rubber or special Teflon as required.
Streamlined travel ways eliminate reverse flow and increase capacity.

The famous Fisher "Big Joe", which enjoys a universal reputation for complete dependability, is the first choice for pounds to pounds service. Inlet pressures up to 1000 lbs. Reduced pressures 5 to 200 lbs.

Write for Catalog P-10

FISHER LEADS THE INDUSTRY IN RESEARCH FOR BETTER GAS PRESSURE CONTROL

FISHER GOVERNOR COMPANY

Marshalltown, Iowa

A MESSAGE TO AMERICAN INDUSTRY

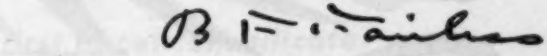
"This is more than a shortage . . . this is an emergency.

Every pound of your scrap is needed, NOW!"

"THE STEEL INDUSTRY is currently operating at more than 100% of rated capacity—turning out well over 2 million tons of steel per week. This record high production—every ton of which is in urgent demand—cannot be kept up unless we get more scrap from every potential source. For without your scrap we cannot produce enough steel. Today, every ton of steel turned out requires a half a ton of scrap for its production. That's why scrap—more scrap—is so urgently needed, and needed right away.

"The fact we have to face today is that steel mills are operating on a hand-to-mouth basis as far as scrap is concerned. Some mills are working on only a two-day supply of scrap. We already have had to shut down steel-making furnaces for lack of scrap.

"That's why we are asking you to strain every effort to get more scrap out of your plants and yards and on its way to the mills . . . to search out the scrap that doesn't come to market in normal times. You'll find this "dormant" scrap in obsolete equipment, tools and machinery that you haven't used for years . . . overlooked in your storage sheds . . . or rusting away in a junk pile in some forgotten corner. It's there. Turn it in at once—*so we can turn out the steel you need.* We can't do it without your help."



President, United States Steel Corporation

USS

UNITED STATES STEEL

WOLVERINE COPPER TUBING *first* ON D.O.

but we're not forgetting YOU

Copper and copper base alloy tubing is specified on many Defense Orders. Wolverine tubing is often selected because it is, as you know, quality-controlled from ore to finished product and, therefore, conforms to the high standards that must be met.

Incidentally, Wolverine has been manufacturing copper and copper base alloy tubing for well over thirty years—for domestic production and in answer to government needs when required.

But like all other manufacturers, we are cognizant of the division of our obligations. Your needs, too, are recognized. Not all the copper tube we produce daily is earmarked for emergency use. The maximum percentage allowed by government regulations is being produced to take care of essential domestic needs—your other needs.

Whatever tube you can get, utilize it to the best advantage. Employ it judiciously and we shall all get along very well until the emergency is over.

WOLVERINE TUBE DIVISION
Calumet & Hecla Consolidated Copper Company
INCORPORATED
Manufacturers of seamless, non-ferrous tubing
1431 CENTRAL AVE. • DETROIT 9, MICH.

Wolverine condenser tubes stocked by
Butler Industries, Inc., 355 So. Fourth St., Beaumont, Texas • Phone Beaumont 5-2351

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
Sales Offices in Principal Cities

Export Department, 13 E. 40th St., New York 16, N. Y.

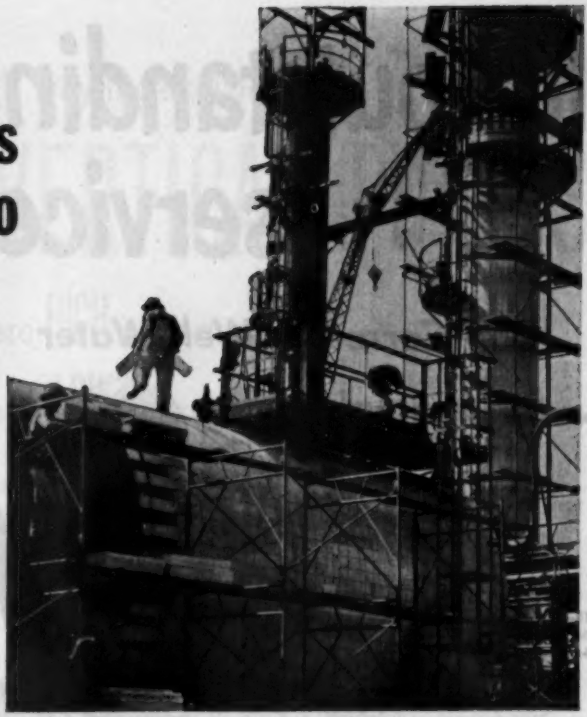
6 Reasons Why

Leading Refiners Are Switching to KAYLO HEAT INSULATION

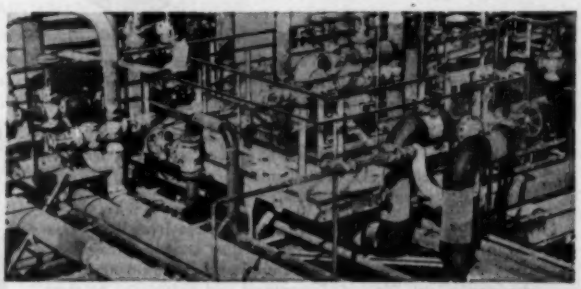
Through demonstrated superiority, Kaylo Heat Insulation is rapidly becoming recognized as the first basic advancement in the high temperature field in many years. Compare these advantages:

- Kaylo Heat Insulation is a calcium silicate (not glass)—an inorganic material which retains its stability in long service under severe conditions;
- Kaylo Heat Insulation has a wide effective temperature range—up to 1200°F.—eliminating need for combination covering in nearly all operating conditions;
- Kaylo Heat Insulation is insoluble in water. Work is not delayed by wet materials;
- High strength of Kaylo Heat Insulation practically eliminates spoilage both in transit and in application. Workmen can walk on insulated equipment without breaking insulation;
- Light weight along with high strength of Kaylo Heat Insulation makes application easier and faster;
- Simplified Dimensional Standards of Kaylo Pipe Insulation permit use of double layers for the higher temperatures without the use of special materials.

It will pay you to investigate the advantages offered by Kaylo Heat Insulation.



Applications of Kaylo Heat Insulating Block and Kaylo Pipe Insulation, The Texas Company Refinery, Lawrenceville, Illinois. M. W. Kellogg Company, New York, Designer and Builder. New construction includes units for fluid catalytic cracking, fractionation, gas recovery and catalytic polymerization.



For complete details on Kaylo Heat Insulation, write Dept. N-168, Owens-Illinois Glass Company, Kaylo Division, Toledo 1, Ohio.

KAYLO. . . *first in calcium silicate*

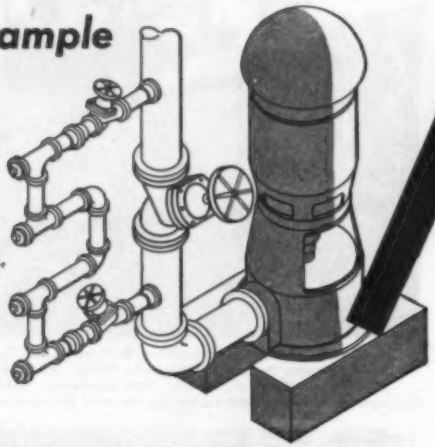
. . . pioneered by OWENS ILLINOIS Glass Company

MAIN OFFICE: TOLEDO 1, OHIO—KAYLO SALES OFFICES: ATLANTA • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND DETROIT • HOUSTON • MINNEAPOLIS • NEW YORK • OKLAHOMA CITY • PHILADELPHIA • PITTSBURGH • ST. LOUIS • WASHINGTON

for outstanding service

on Corrosive Well Water

...for example



The Installation—
Barr Rubber Products Co.,
Sandusky, Ohio

PROBLEM: To eliminate costly seating and packing maintenance, and frequent replacement of valves on plant well-water pump. Valves previously used highly unsatisfactory, having maximum life of 6 months.

WORKING CONDITIONS: Sulphur content of water extremely high. Valve constantly exposed to severe corrosive and erosive effects. Operated infrequently; yet easy operation, positive seating are prime requisites.

SOLUTION TO PROBLEM: Crane Packless Iron Body Diaphragm Valves featuring separate disc and diaphragm design. Three-inch No. 1611 flanged end valve on main discharge; ¾-inch No. 1610 screwed end valves on by-pass.

RESULT: While other valves lasted only 6 months or less, Crane Diaphragm Valves show no effects of service, after more than a year. They operate smoothly . . . seat tightly . . . no maintenance whatsoever needed to date!

Another typical demonstration of superior quality, and the low-cost performance of Crane Valves. That's why . . . More CRANE VALVES are used than any other make!

...Choose Dependable CRANE VALVES

No. 1611 Crane Iron Body Diaphragm Valve —one of a full line suited for many services. Literature on request from your Crane Branch or Crane Wholesaler.

CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Why Ingersoll-Rand

VERTICAL PUMPS

are HIGH in performance

and LOW in installation and maintenance

OPERATION IS BETTER

These rugged, vertical process pumps have repeatedly proved their dependability and unusually high economy in refineries the world over. The shaft and impeller assembly is in complete radial balance. And positive alignment is maintained by accurate machined fits of all mating sections. The proven design of these units—with each part of the most suitable material for the application—assures *sustained* high efficiency.

INSTALLATION IS EASIER

The in-line arrangement of suction and discharge nozzles permits simple, straight-through piping—without loops or elbows. Piping can be located above or below floor level, as desired. Compact, vertical design conserves space—eliminates the need for large foundations, bedplates and grouting.

MAINTENANCE IS SIMPLIFIED

There is only one stuffing box—easily accessible through openings in the discharge head. Either conventional packing or the I-R Cameron Shaft Seal can be used. There is no thrust bearing to maintain, residual thrust being taken by the motor bearing. And the segmented inner casing assembly is easy to dismantle and assemble for inspection or servicing. Maximum interchangeability of impellers and diffusor sections reduces spare parts inventories.

The inherent advantages of vertical design particularly suit these pumps to many refinery and process services. Your nearest Ingersoll-Rand branch office engineer will be glad to study your next pumping problem with you. Whether the solution indicated calls for a vertical or horizontal unit, you are assured of obtaining the *right* pump for the job when you specify Ingersoll-Rand.

Ingersoll-Rand

CAMERON PUMP DIVISION
11 Broadway, New York 4, N. Y.

588-10

THERE'S AN I-R CENTRIFUGAL PUMP FOR EVERY REFINERY NEED

Single-stage, vertically split
Capacities—20 to 550 gpm
Pressures—to 300 psi

Single- and two-stage, vertically split
Capacities—10 to 3000 gpm
Pressures—to 600 psi

Single- and two-stage, horizontally split
Capacities—20 to 3500 gpm
Pressures—to 500 psi

Multi-stage, with cylindrical "double-case" construction
Capacities—to 2800 gpm
Pressures—to 3000 psi

COMPRESSORS — — AIR TOOLS — ROCK DRILLS — TURBO BLOWERS — CONDENSERS — CENTRIFUGAL PUMPS — DIESEL AND GAS ENGINES

Take advantage of DuPont Technical Services TO REDUCE ANTIOXIDANT TREATING COSTS!

Gasolines vary in their response to antioxidants. That's why Du Pont not only makes several types of antioxidant, but also supplies complete technical service in connection with their use.

THE DU PONT LABORATORIES, for example, have had many years of valuable experience in working with refiners on their antioxidant treating problems. They will be glad to evaluate your gasoline to determine the most effective antioxidant for your particular stock. In many cases, their recommendations have resulted in substantially lowered treating costs.

IN ADDITION, Du Pont technical representatives are available to you for at-the-plant assistance. Because of their special training and wide experience, these men are prepared to help you solve any additives problem economically.

MANY YEARS OF MANUFACTURING EXPERIENCE have gone into the development of Du Pont Antioxidants. Since the early 20's, the extensive research facilities of Du Pont have been working closely with the Petroleum Industry on antioxidant improvements. As a result, you can always depend on Du Pont Antioxidants for uniform quality and low-cost efficiency.

3 CONVENIENT SHIPPING POINTS—Du Pont Antioxidants are available from warehouses in Houston, Texas; Los Angeles, Calif.; and Wilmington, Del.

Chemical section of one of the five Du Pont District Laboratories.

NOW AVAILABLE AT NEW LOW COST!
The price of all Du Pont Antioxidants has recently been reduced . . . Write today for full details.

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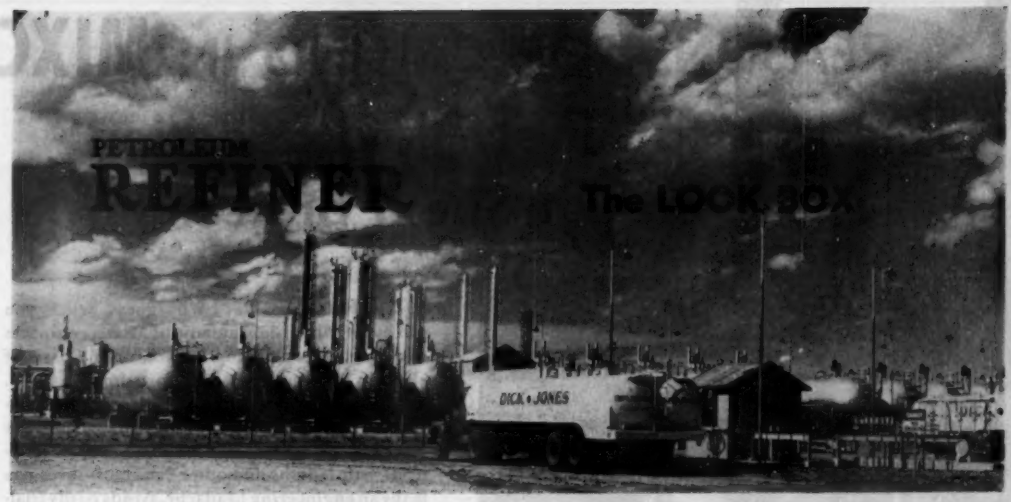


INEFFICIENT use of America's synthetic rubber plants cost the consuming public an additional $500 million for the year ending May 1, 1951, P. W. Litchfield, chairman of the board of The Goodyear Tire & Rubber Company has disclosed.

Needs for Expanded Synthetic Rubber

Litchfield, reviewing the current situation in a new issue of his "Notes on America's Rubber Industry," points out that skyrocketing prices of natural rubber last year resulted from inadequate synthetic production, inventories and stockpile. By means of a study of supply and demand in rubber over past decades, he emphasizes the need for an aggressive program of expansion in synthetic rubber production over the next 10 years.

In 1946 our American synthetic rubber plants produced 762,000 long tons for current consumption, in addition to providing a stockpile of 115,000 long tons. Because of this large production of synthetic, the price of natural rubber in that year was 22½ cents per pound.

However, during the next four years synthetic plants were gradually closed down, until a low point was reached in January, 1950, when the total output of synthetic (GR-S) during the month was only 19,000 tons. Then in 1950 there was a sharp rise in the demand for rubber. Production of new automobiles soared, consumption of gasoline mounted, and demand for rubber products of all kind sharply reflected these key impulses. Civilian America went into the market for an unprecedented 1,259,000 long tons of new rubber. As a result the price of natural rubber rose to 73 cents per pound in November, 1950.

Since that time, fortunately, the pressure has diminished. Synthetic plants are being restored to capacity production, and the government stockpile is nearing sufficiency. As a result natural rubber has dropped to 50 cents and is still falling.

However, even though we now seem to be on the eve of happier prospects, Litchfield warns that this is only a breathing spell. Looking ahead to 1960 he predicts a world market for 4 million long tons. Further, there seems to be little prospect for substantial expansions of natural rubber production. "Thus we are left with only one way out," he concludes, "facilities for the production of synthetic rubber must be greatly expanded."

THE May 1951 issue of *The Beacon*, The Ohio Oil Company's monthly magazine includes a letter purported to have been written by a thoughtful observer who in 1859 stood in an excited crowd watching a bearded man in a stovepipe hat direct a queer and unusual operation—pumping a dark green liquid from under the surface of the earth. The man eventually hurried to his room in the town's one hotel to compose the letter:

Haste, Brother—Then as Now

Titusville, Pa.
September 1, 1859

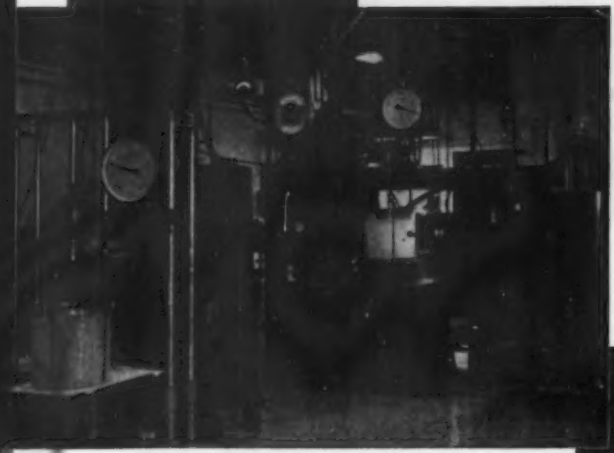
My dear Brother: This man Drake from New England who has been here drilling a Hole in the Ground, has bored through to a spring of Rock Oil. It is true; I saw him pump out several Bbls. yesterday and even more today. I am determined to try my own hand at this, and if you want to join in the venture, come at once. By all means, hurry before Drake has got it all out. Of one thing you may be certain, the Supply is fast diminishing. Therefore, Brother, make haste . . .

Then, with the first commercial oil well, as it is

Top-of-Page-Photo—View of Stanolind Oil & Gas Company Natural Gasoline Plant Located near Elk Basin, Wyo.

2 REASONS FOR CALLING IN MIXCO

to supply fluid agitation on your next project

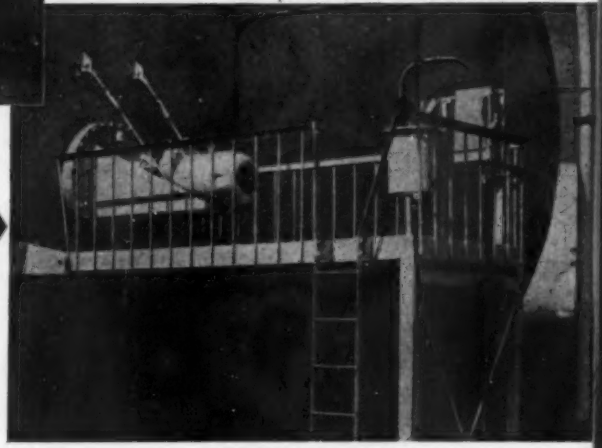


MIXCO research and development laboratory

1. TECHNOLOGY . . . Why guess, when you can be *sure* about fluid agitation? Mixco engineers choose correct agitation for you on the basis of viscosity, specific gravity, proximity, speed, power consumption and many other carefully considered factors. Exclusive Mixco data on impeller pumping capacities, critical shaft speeds, practical shaft lengths and other variables, saves you many an engineering headache, avoids costly trial-and-error, and gives you best possible agitation at minimum power cost. Results are *guaranteed!*

2. EQUIPMENT . . . The Lightnin Mixer shown here is one of three 25-HP units that blend a 100,000-barrel Spheroid to uniformity in less than two hours, with substantial savings over recirculating pumps.

Lightnin Mixers last from 10 to 20 years, according to their service. They are easily repacked from outside the tank, without draining tank. Standard stuffing boxes are furnished for abrasive and corrosive conditions. Write today for assistance on any fluid agitation problem, and for helpful literature on Lightnin Mixers.



LIGHTNIN side entering mixer

MIXING EQUIPMENT Co., Inc.
(MIXCO)
164 Mt. Read Blvd., Rochester 11, N. Y.
In Canada: William & J. G. Greey, Ltd., Toronto

Please send me the literature checked:

- ☐ B-76 Side Entering Mixers
- ☐ DH-50 Laboratory Mixers
- ☐ B-78 Top Entering Mixers (Propeller Type)
- ☐ B-52 Condensed Catalog showing complete line
- ☐ B-89 Top Entering Mixers (Turbine and Paddle Type)
- ☐ B-75 Portable Mixers (Electric and Air Driven)

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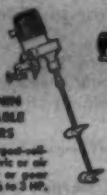

LIGHTNIN PORTABLE MIXERS
World's largest-selling line. Electric or air motor, direct or gear drive. Sizes ¼ to 3 HP.

LIGHTNIN SIDE ENTERING MIXERS
For tanks up to 5 million gallons. Gear motor or V-belt drive; explosion types. Sizes 1 to 25 HP.

LIGHTNIN TOP ENTERING AGITATORS
Turbine, propeller and paddle types. For open or closed tanks. 16 speeds available in gear heavy duty drive. Sizes ¼ to 500 HP.

A COMPLETE LINE . . . UNEXCELLED TECHNOLOGY

today, *The Beacon* points out, there were calamity howlers predicting the immediate using up of all our petroleum. Yet today, 92 years after the drilling of the Drake well, United States petroleum reserves are at a new peak. The American Petroleum Institute and the American Gas Association in a joint report estimated proved reserves of liquid hydrocarbons at the close of 1950 at 29½ billion barrels.

To Know Is To Understand

TWO weeks "behind the scenes" is the offer made by Standard Oil Company of California in inviting representative educators from more than a dozen major western universities and colleges to take a first hand look at the oil business. Conferences in San Francisco with top management, field trips to a refinery and to the oil fields of the San Joaquin Valley, as well as a visit to a training school for new employes of Standard Stations, Inc., should give the educators a better understanding of the oil industry's aims and problems as regards its place in industry, in the community and in the nation.

This is not the first such offer made by a major company to the field of education. DuPont earlier this year announced it would invite several professors to spend twelve months in DuPont plants acquainting themselves with the common tools and language of the chemical industry, so that returning to the classroom, they might pass on a deeper insight into the problems faced by industry as well as a practical understanding of the know-how typical of that field.

These companies are using a practical and expedient avenue of reaching the public with full and proved information that should provide a solid basis upon which better understanding of industrial problems and aims may grow.

It is hoped that this plan will prove as effective as its sponsors hope. Certainly it has the making of paying off handsomely in public support of an industry whose purposes and accomplishments are not nearly well enough known.

Oil Progress Week, 1951

SPECIAL materials are being prepared by the Oil Industry Information Committee for the observance of Oil Progress Week, which this year will be October 14-20.

Thousands of oil companies will participate in the week's program, which will include special events at service stations, bulk stations, refineries and company plants. Informing the public of the progressiveness of the oil industry and its service to the nation will be the objective of hundreds of thousands of oil men and women.

Every communication medium, including motion pictures, will be utilized by the industry in telling its story. Those who take part in the week's events will promote better public understanding of one of the nation's most significant industries and enhance their own stature and security in their jobs, the OIIC believes.

Good progress both in developing this annual program and the resulting benefits from such activities have been noted since OIIC started this "week" a few years ago. "Oil" now is definitely linked with "progress" in the public mind but these intensive periods of industry activity are needed as clinchers.

On Our Toes Then and Now

WHERE the oil industry stands today, and how oil men are fighting a tremendous production battle to keep America well supplied with petroleum products are spelled out vividly in a new folder just released by the Oil Industry Information Committee of the American Petroleum Institute.

Entitled "On Our Toes," the new folder states emphatically that the men and women of oil are ready to serve this country no matter what happens, and that the industry itself is better prepared than ever before to meet any emergency.

The oil industry can certainly be proud of its accomplishments during World War II, as the following facts attest: "Two out of every three tons of material shipped overseas to our fighting forces and to our allies were oil products . . . It is estimated that it took more than 22 billion gallons of oil to conquer Germany . . . Planes of the 9th Air Force alone consumed an average of 634,000 gallons of high octane gasoline daily . . . Ships of the U. S. 5th Fleet burned 630 million gallons of oil in just seven weeks." This was of course in addition to supplying all essential civilian needs.

Yet in spite of the huge production of oil products during the last war, the industry is today producing and marketing 25 percent more oil and oil products than at the peak of World War II. Furthermore, the demand is still increasing, and it is estimated that by the end of this year consumption will be 20 percent greater than in 1949.

The folder re-affirms the industry position that all military requirements can be met if the country should be forced into all-out war. It also says that while the industry may not be able to supply every individual with all the oil he wants, there should be enough for all essential civilian requirements, should war come. The job ahead is certainly going to be a challenge, but to meet this the oil industry is "On Its Toes." This folder is being made available by the API to oil companies and trade associations at cost.

• • • the separation of hydrocarbons or other organic chemicals, should be designed for efficiency in terms of overall operating costs and amortization of capital investment. Tray efficiency, cleaning facility and resistance to corrosion are the prinicipal factors to be considered. For practical purposes, tray efficiency or tray spacing may be reduced to keep tower cost at a minimum. A balance of utility costs against chemical recovery may indicate the desirability of sacrificing some of the recoverable material, with a corresponding reduction in the capital outlay for columns and associated calandrias, condensers and heat exchangers. Particularly when potential changes in process or product specifications are foreseen, distillation columns with sectional shells and removable trays of light alloy construction offer special opportunities for economy because of the ease of transfer from tower to tower as well as cleanability and resistance to corrosion.

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Memo to Refiners:

Discovery Task Tremendous, Heavier Imports Not Unlikely

THE STERN relation of drilling to production schedules has been given new emphasis by the increasing difficulty of finding oil in the United States. Recent trends have shown a steady decrease in volume discovered per discovery attempt. Large quantities of oil continue to be found only because of a greatly accelerated effort on the part of drilling segments of the industry. Although wildcat drilling has doubled since the war, the volume of oil discovered has not increased significantly as a result, and stepped up wildcatting has burdened the industry financially with twice as many dry holes annually. At the present time failures constitute more than one third of all drilling operations.

The highly important truth is that fewer barrels of oil are being found in relation to skyrocketing consuming and producing rates. Last year a record 6.8 million barrels per day of oil were consumed in the U. S. All trends indicate that consumption will increase steadily until 8,350,000 barrels will be demanded by 1955, with perhaps a minimum level of 10 million barrels per day by 1960.

Declining Discovery Ratio

Before the war an average of two barrels of oil were discovered for every barrel produced. This ratio dropped to 1.6 barrels during the postwar period, and last year dropped to 1.3 barrels. This is a situation requiring attention, for experience has proved that it is necessary to maintain a ratio of 1.8 barrels discovered for each barrel produced in order to hold the country's reserve position. So although the number of barrels of crude added to the nation's reserve has increased steadily, it has not increased in proportion to the rising rate of production.

Discovery rates boosted crude reserves from 15½ billion barrels in 1937 to 19½ billion in 1946, and ran the reserve count up to 25¼ billion barrels in 1950. The figures would seem to indicate a healthy trend until you compare the production rates during this period. Before the war the ratio between proved reserves and annual production was 14 to 1. Last year the ratio dropped to 12.8. In order to restore the ratio of 14 to 1 the reserves must be raised to 31 billion barrels by 1955. This means that the industry needs to discover 6 billion barrels more than it produces during the next five years—a tremendous task.

Enormous Task Ahead

It is estimated that production can reach 6.1 million barrels daily by 1955, based on the present rate of production. Therefore discovery rates must be increased sufficiently to average 4 billion barrels yearly by that time if 1.8 barrels are to be discovered for every barrel produced. By 1960 the discovery rate must be stepped up to almost 4½ billion barrels per year. Such discovery rates have never been maintained in the past, an indication of the enormity of the task ahead.

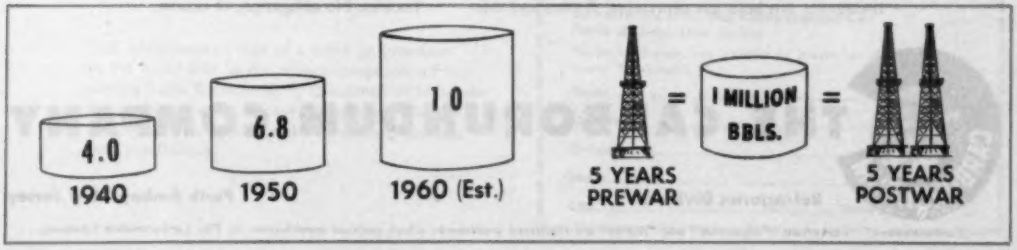
A CONDENSATION of the discussion, "Industry Faces Big Future Discovery Task," by Warren L. Baker, editorial director of WORLD OIL, and published in that magazine in June, 1951, this article contains material which should prove of great interest to domestic refiners as well as those refiners having no export connections. While the figures may prove to be in the realm of pure speculation, they are based on a projection of present trends and serve to point out the broad outline of the magnitude of the oil discovery task and its definite and direct relationship to the refining process.

Declining discovery rates indicate that the U. S. must increase its drilling rates sharply in the future if enough oil is to be found to enlarge its producing ability sufficient to satisfy requirements in the years ahead. Drilling rates since the war have been stepped up to all time highs, and wells completed during 1950 alone totaled 42,000, in contrast with a prewar peak of 32,305 in 1937. But the 1950 drilling represented only 21.3 wells per million barrels produced during the year, whereas the 1937 figures constituted 25.3 wells per million barrels produced. If discovery trends continue downward in the future, the country appears to be confronted with the necessity of increasing its drilling to at least 22.5 wells per million barrels produced by 1955 to offset rising production rates. This would mean approximately 50,000 wells must be completed annually on the basis of producing 6.1 million barrels daily.

The need to increase the ratio of drilling to production likely will continue. If drilling rates reach the neighborhood of 23.5 wells per million barrels production by 1960, then U. S. drilling must be stepped up to around 57,000 wells yearly if production reaches 6.7 million barrels per day.

Under such conditions, a much sharper increase in wildcat drilling seems imperative. In 1950, nearly four wildcats were completed for every million barrels produced, the highest ratio in history. The prewar peak was 2.4 wildcats completed per million barrels production in 1941. This declining relationship between discovery and production presages the need for continuing an upward trend in wildcat drilling. As a consequence, needs may range somewhere in the neighborhood of five wildcats per million barrels produced in 1955, which would mean the completion of approxi-

• See DISCOVERY, Page 60



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○ **for light weight**

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If light weight—or good insulation at very high temperatures—interest you, here's a material worth knowing about. ALFRAX BI aluminum oxide refractory is literally made of bubbles.

Aluminum oxide, as you know, is inherently capable of withstanding very high temperatures—well over 3000° F. We make hollow spheres of Al_2O_3, specially bond them together, and get a finished refractory that has low heat capacity, good load strength, and is one of the best insulating materials available for high temperature jobs. And, a nine inch straight ALFRAX BI brick *weighs only 4.8 lbs.*

These unusual properties have made ALFRAX BI refractories ideal for such diverse applications as: Linings for chemical process kettle settings; Arches for aluminum reverberatory furnaces; Backing-up linings for synthesis gas generators; Arches and sidewalls for ceramic kilns. The one common denominator in each case being high heat — usually above 2600° F. (At lower temperatures, standard materials may prove adequate.)

Do any of these applications strike a responsive chord—perhaps where closer heat control is indicated? . . . or where a reduction in overall lining thickness would pay off? . . . or where a low heat capacity lining is desired?

Whatever your needs, bear in mind that ALFRAX BI refractory is only one of many Super Refractories by CARBORUNDUM — each of which (see box, opposite page) has unique properties ideally suited to certain applications.

Information is now available on all these Super Refractories. So send today for our valuable new booklet. No obligation, of course.

THE CARBORUNDUM COMPANY

Refractories Division • **Perth Amboy, New Jersey**

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refractory material made of bubbles!

SUPER REFRACTORIES ARE ALSO USED

WHERE ABRASION OR EROSION IS SEVERE. Two Super Refractories—CARBOFRAX silicon carbide material and MONOFRAX K fused cast material—are within one index point of diamond hardness! As a result, both are exceptionally resistant to abrasion, either at room temperature or high heat.

WHERE HEAT CONDUCTIVITY IS NEEDED. At elevated temperatures CARBOFRAX refractories conduct heat as rapidly as chrome-nickel steels! This characteristic is invaluable in checkers, muffles, hearths, etc.

WHERE CHEMICAL ATTACK IS LIKELY. In general, all Super Refractories are either neutral or acid in nature—are widely used where chemical inertness is important.

WHERE STRENGTH IS IMPORTANT. No commercial tonnage refractories have greater strength than Super Refractories. All can withstand over 300 psi at 2750° F without crushing.

WHERE HIGH HEAT IS INVOLVED. They can be safely used at temperatures over 3000°F. They are very durable—are highly resistant to spalling and cracking. Some varieties are almost indispensable where flame impingement or violent temperature changes are present.

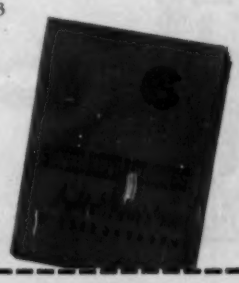
WHERE SPECIAL SHAPES ARE INDICATED. Practically all Super Refractories are available either as bricks or special shapes molded to close tolerances—including fitted joints, tubes, etc.

Do any of these suggest possible applications?

The important thing about Super Refractories by CARBORUNDUM is NOT just that they are "better" than standard fireclay refractories. The important thing is that they are actually *a class apart*—with many entirely different properties and applications. (For example, some of their properties—such as abrasion resistance—are important *regardless of whether high temperatures are involved.*)

Nor is their principal value simply that they cure trouble-spots where other materials (e.g., refractories, metals, etc.) fail to stand up. Their value usually lies in increasing capacity and reducing overall operating costs. (For example, regenerator checkers made of CARBOFRAX silicon carbide brick absorb and release over 3 times as much heat as checkers made of ordinary refractories when cycles are short.)

WHY NOT CHECK UP? We have a new booklet which outlines the unusual characteristics of these special purpose materials. The coupon will bring you the story—or one of our engineers will be happy to talk over your specific problems. We believe it could be mutually profitable.



This advertisement—one of a series—is presented in the belief that in the unusual properties of the various Super Refractories by CARBORUNDUM lies the key to many new or improved processes. We would like to talk over specific jobs with anyone who sees such possibilities.

Dept. T-81
Refractories Div., The Carborundum Co.
Perth Amboy, New Jersey

Please send your free booklet on properties of Super Refractories.

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Company_____

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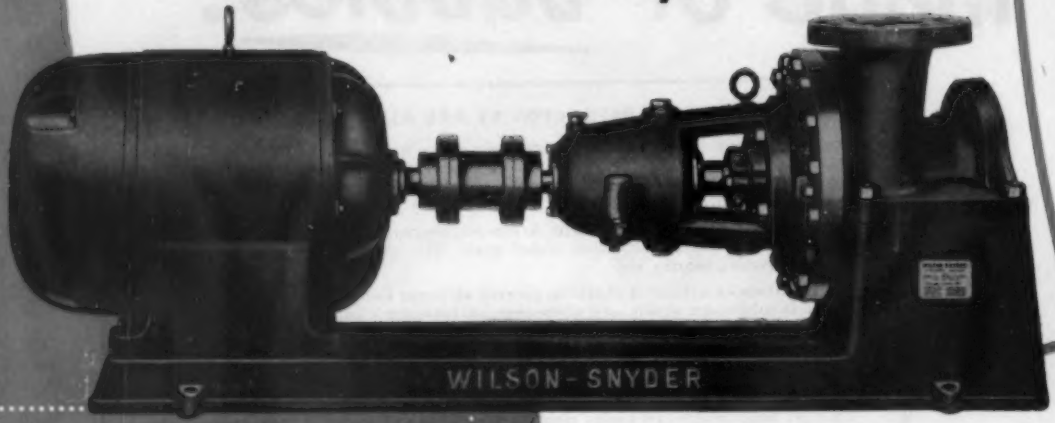
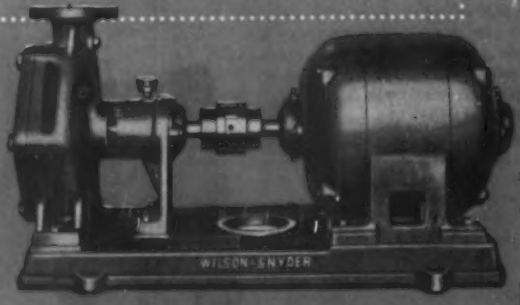
Proven Centrifugal Process Pumps added to Wilson-Snyder line



TYPE ES . . . 14 sizes . . . Maximum interchangeability . . . Minimum parts inventory . . . . Capacities to 1600 GPM . . . Heads to 725 feet . . . Temperatures to 900°F. . . . Suction pressures to 600 psi . . . Discharge pressures to 900 psi.

TYPE CS . . . 6 sizes . . . Maximum interchangeability . . . Minimum parts . . . Capacities to 550 GPM . . . Heads to 150 feet . . . Temperatures to 200°F. . . . Discharge pressures to 200 psi.



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For Refinery and Chemical Processing and General Service

OIL WELL SUPPLY COMPANY has acquired the complete line of Type ES and CS Centrifugal Pumps formerly manufactured by National Transit Pump and Machine Company, Oil City, Pa.

These pumps are being engineered and manufactured at our Braddock, Pa., Plant as WILSON-SNYDER Type ES and Type CS Centrifugal Pumps. Genuine renewal parts for pumps of this type previously manufactured by National Transit are available from us.

INQUIRIES . . . can be directed to your nearest "Oilwell" representative or to Wilson-Snyder at Braddock, Pa.

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UNITED STATES STEEL

News Notes on Refinery and Other Plant Construction

Petroleum Refiner's Next "Box Score" Tabulation Will Appear in the October Issue

Arasorb Process Outlined; Sun Will Construct Unit

The "Arasorb" process, designed to separate aromatics, announced last month by Sun Oil Company, will be available to industry generally through a licensing program under Sun's patent rights.

Benzene already is in short supply and, officials said, in event of another war, other aromatics, especially toluene and xylenes will become "must" for both military and essential civilian pursuits.

The Arosorb process is a development by Sun of the analytical tool of silica gel adsorption used so successfully by Dr. F. D. Rossini, of the API's Project No. 6 in his work on the analysis of petroleum. This technique was further developed extensively by Sun as an analytical procedure and, recognizing the possibilities of commercialization, its research teams spent more than eight years in developing the present process.

The new process will be incorporated in a new plant costing in excess of $8 million soon to be erected at Sun's Marcus Hook refinery, the new plant to couple an Arosorber with a 10,000-barrel-per-day Houdriformer. The Arosorber will concentrate and purify the aromatics to specification products. Annual capacity of the new plant will be 13 million gallons of benzene, 30 million gallons of toluene, and 15 million gallons of xylenes. It is expected to be completed late next year.

The Arosorber has great flexibility which permits adapting it to the recovery of other products such as DDT solvents and other solvents, improved furnace and diesel oils. The Arosorber can also be used by the chemical and other industries for the separation of chemicals otherwise difficult to recover or purify.

The new process will be the first large scale commercial application of selective adsorption utilizing silica gel. Silica gel, a synthetic amorphous form of silica, is unusually effective in preferentially adsorbing one type of compound from a mixture of several types. Each particle of silica gel has countless micropores averaging about one ten-millionth of an inch in diameter. These pores offer surface area for adsorption of about 90 acres per pound. Because of size, weight or arrangement, each type of molecule is held by the silica gel with a differing degree of tenacity. From this property is derived the term "selective adsorption."

Shell Increases Output Of Sulfonates at Martinez

Additional facilities for the manufacture of oil soluble sodium sulfonates went on stream recently at Shell Oil Company's Martinez, Calif., refinery.

Heaviest demand for sulfonates is as additive for heavy-duty lubricating oils as it prevents deposits from forming in motor engines, valves and pistons. Automobile manufacturers recommend sulfonate-containing oils for long engine life and the government requires additive-type lubricating oils.

The Martinez refinery was one of the first to manufacture sulfonates as a primary product from petroleum.

Nebraska Plant Starts

A stripping plant with a processing capacity of 13 million standard cubic feet every 24 hours has been completed for Ohio Oil Company at its Sidney, Neb., refinery. The plant cost $600,000.

Cities Service Authorizes Two Hydroforming Units

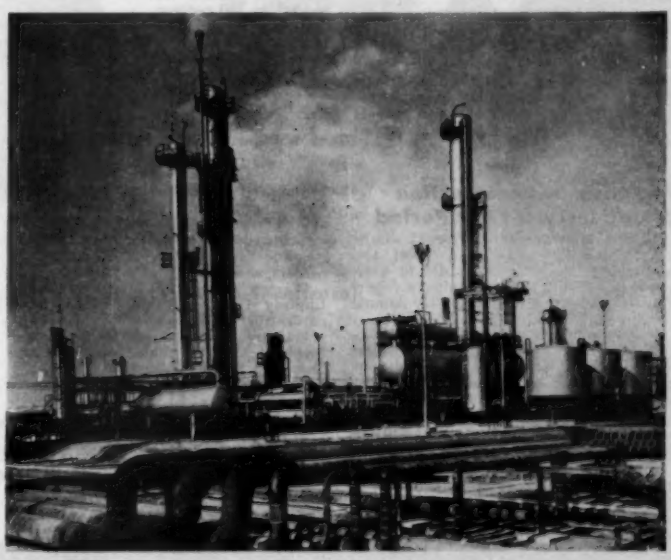
Cities Service last month authorized The M. W. Kellogg Company, New York, to proceed with the design and engineering of two large-capacity Fluid Hydroforming units. One, located at Lake Charles, La., will process more than 800,000 gallons daily, while the other, at East Chicago, Ind., will handle about half this volume. This new process is aimed to meet the problem of upgrading low octane gasolines.

According to Kellogg, the new Fluid Hydroforming process can reform 55 octane naphtha to automotive gasoline with a clear octane rating of 95 CFR-R (without any tetraethyl lead). If an aviation gasoline product is desired, the process can produce fuels with rich-mixture aviation octane ratings of over 175 with the addition of 4.6 cc of tetraethyl lead.

Sun Oil Company Will Build $10 Million Plant at Sarnia

A refinery to process from 10,000 to 15,000 barrels of crude daily will be built by Sun Oil Company at Sarnia, Ontario. The plant, which will cost about $10 million, will make high quality motor gasoline, kerosine, domestic heating oil and residual, and also light hydrocarbons for use by Polymer Corporation of Sarnia.

Construction depends on the availability of materials, but March, 1953, has been set as the tentative completion



EAST'S ALKYLATION PLANT—The East's first postwar alkylation unit—a more-than-2000-barrel-per-day plant for California Refining Company's Barber Refinery in Perth Amboy, N. J.—has just recently been placed on stream, according to The M. W. Kellogg Company, New York City, which designed and erected the equipment. Shown in the above photo, the plant was originally planned to help meet the "octane challenge" of the higher compression engine. Half way through construction it was slightly modified by the addition of a re-run tower for splitting the alkylate into light and heavy fractions because of increased military requirements for aviation gasoline.

date. Catalytic Construction Company, Philadelphia, is principal contractor.

The Sarnia plant will consist of combination atmospheric and vacuum distillation units and an 8000 to 10,000-barrel-a-day Houdriflow catalytic cracking unit.

Site of the new plant is a 120-acre tract fronting on the St. Clair River.

Operating Agreement Set For Refinery in Colombia

International Petroleum (Colombia) Ltd., subsidiary of International Petroleum Company, Ltd., has made an agreement with Colombian National Petroleum Company (Empresa Colombiana de Petroleos), under which International will occupy, use and operate with complete autonomy the present 18,000-barrel per day refinery at Barrancabermeja which reverts to the nation August 25 under the terms of the De Mares Concession.

The fixed annual fees paid by International Colombia will vary with the amount of raw materials treated, L. P. Maier, president of both International companies, said.

The agreement, which runs for ten years from the date International takes over the plant, calls for Empresa to construct facilities to process 35,000 barrels of crude, including a pipe still, visbreaker, Fluid catalytic cracking unit, light ends recovery unit, aviation alkylation unit, and other improvements costing about $20 million U.S. International Petroleum will lend Empresa $10 million to be repaid over a ten-year period.

International Colombia will buy crude from Empresa and will sell refined products required for Colombia consumption under Colombian price control regulations. Products and reduced crude not sold in Colombia may be exported. International Colombia will also provide Empresa with technical assistance at cost on crude production.

Increase In Construction Noted In Two-Year Period

The oil refining industry spent almost $90 million more for new plant and equipment in 1949 than it did in 1947, it was revealed in a preliminary report from Census Bureau on the 1949 Annual Survey of Manufacturers.

Of the total 1949 expenditure of $403,455,000, about 70 percent ($284,076,000) went for new structures and additions to plants, with the remaining $119,379,000 for new machinery and equipment.

In 1947, $271,939,000 (about 86 percent) was for structures and additions and $44,431,000 for equipment.

Census Bureau figures did not include non-manufacturing establishments of of manufacturing companies, plants not in production during 1949, or plants or equipment acquired by lease from owners.

Richfield May Expand

Richfield Oil Corporation, Los Angeles, is reported to be considering a $45 million refinery improvement program. If carried out, construction would take two years.

Fast Tax Write-Off Authority Is Granted Refining Companies for Varied Projects

Several score more fast tax write-offs were given by the Defense Production Administration upon recommendation of PAD during the month of June to United States oil companies for units that will be used, at least to a degree, in producing items needed for national defense.

Issued July 3:

Standard Oil Company of California—Richmond, catalytic cracking unit (7500 b/d) $9 million, at 70 percent.

Socony-Vacuum Oil Company—Paulsboro, N. J., aviation gasoline, $911,000 at 85 percent.

Texas Natural Gasoline Corporation—Jones and Fisher counties, Texas, natural gasoline, $1,132,700 at 75 percent.

Phillips Petroleum Company—Brazoria County, Texas, natural gasoline, $6,094,710 at 75 percent.

Issued July 9:

Socony-Vacuum Oil Company—Buffalo, basic refining equipment, $4,588,000 at 55 percent.

Socony-Vacuum—Brooklyn, basic refining equipment, $4,640,000 at 55 percent.

Socony-Vacuum—East Chicago, basic refining equipment, $4,610,000 at 65 percent.

Gulf Oil Corporation—Pittsburgh, natural gasoline, $606,486 at 75 percent.

Phillips Petroleum Company—Sherman County, Texas, natural gasoline, $6,014,416 at 55 percent (lower certification because gathering lines are involved).

Humble Oil & Refining Company—Baytown, Texas, toluene and xylene, $64,941 at 100 percent.

Crown Central Petroleum Company—Pasadena, Texas, ethylene and propane-propylene, $265,000 at 70 percent.

McKamie Gas Cleaning Company—Magnolia, Ark., butane, $1,772,483 at 75 percent.

Shell Oil—Beckham County, Okla., natural gasoline, $4,544,000 at 70 percent.

Issued July 16, 1951:

Standard Company of California—Kern County, Calif., iso-butane, $320,711 at 75 percent.

Leonard Refineries, Inc.—Alma, Mich., gasoline (two parts), $2,723,500 at 75 percent and $388,500 at 55 percent.

Warren Petroleum Corporation—Lindsay, Okla., gasoline, $261,337 at 60 percent.

Magnolia Petroleum Company—Stephens County, Okla., natural gasoline, $445,000 at 75 percent.

Eastern States Petroleum Company—Houston, avgas, $3,300,000 at 100 percent.

Warren Petroleum Corporation—Holliday, Texas, gasoline, $389,819 at 90 percent.

Phillips Petroleum Company, Hutchinson County, Texas, avgas (two parts), $139,715 at 100 percent and $57,115 at 50 percent.

Ohio Oil Company—Matagorda County, Texas, propane, $4,108,414 at 70 percent.

Pontiac Refining Company—Corpus Christi, Texas, gas, oil $445,000 at 75 percent and $30,000 at 50 percent.

Pontiac Refining Company—Corpus Christi, gasoline, $260,000 at 75 percent and $15,000 at 50 percent.

Wilcox Oil Company—Bristow, Okla., octane Platformate (two parts), $830,000 at 75 percent and $50,000 at 50 percent.

Issued July 23:

Mid-Continent Petroleum Corporation—Tulsa, alkylation facilities, $817,274 at 100 percent.

Davison Chemical Corporation—location not specified, catalytic cracking, $4,301,512 at 85 percent and $858,238 at 50 percent.

Issued July 30:

Tide Water Associated Oil Company—Bayonne, N. J., petroleum storage, $2,265,872, at 50 percent.

Gulf Oil Corporation—Port Arthur, Texas, isoctyl alcohols, $74,756 at 80 percent.

Gulf Refining Company—Cleveland, Ohio, heptene, $272,216 at 80 percent.

Skelly Will Add New Unit To Refinery at Longview

An approximate 20 percent increase in crude capacity is expected to result from the expansion and modernization program planned by Skelly Oil Company for its refinery at Longview, Texas.

Included in the project are plans for installing a 1500-barrel-per-day charge capacity Platforming unit, and a catalytic polymerization unit of adequate size to balance the refinery operation.

Universal Oil Products Company and its subsidiaries will handle the design, engineering and construction of equipment. Completion of the program is tentatively scheduled for the latter part of March, 1952.

Shell Sends Engineers To Open Grangemouth Plant

The Shell organization dispatched four chemical engineers to Grangemouth, Scotland, last month to start-up the new multi-million dollar synthetic ethyl alcohol plant there. The Grangemouth plant is a major unit in the current expansion program of Britain's chemical industry. Operating under Shell license, it uses the direct hydration process worked out at Shell Development for Shell Chemical Company's Houston plant.

The chemical engineers were, from Shell's Emeryville, Calif. refinery: C. R. Nelson, M. L. Courter, and M. E. Stromsmoe. R. B. Hanning was on loan from Shell Chemical Corporation's Houston ethyl alcohol plant.

Propose Manila Refinery

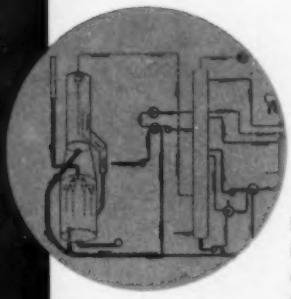
Caltex Oil Company proposes to build a 16,000-barrel-a-day refinery in the Manila area, to process Sumatra crude, and has requested permission of both the U. S. and Philippine governments to proceed with the project.

Modernization Plan Begun

A 2000-barrel-per-day increase in output is anticipated when Kanotex Refining Company completes the $2.3 million

one contract

one contractor



From flow diagram to finished unit a Foster Wheeler contract provides experienced engineering service for every detailed step in the sequence of design, procurement, fabrication and construction.

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another complete refinery

Foster Wheeler is pleased to announce that it will design and construct a complete refinery for the Standard-Vacuum Refining Company of South Africa (Pty.), Ltd. at Durban, Union of South Africa.

The outstanding processing feature of this new refinery is a combination crude distillation-catalytic cracking-thermal reforming unit. The cracking unit will be the new Fluid design:—Model IV.

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modernization program now under construction at its Arkansas City, Kansas, refinery. Added facilities will bring capacity to about 12,000 barrels per day. Completion date is June, 1952.

Burmese Refinery at Chauk Rebuilding from Salvage

At Chauk in Upper Burma, the Burmah Oil Company is installing several new units designed to shorten waste residue from the existing 30 down to 6 percent. When completed the refinery will distill and refine 3000 barrels per day of crude oil to produce gasoline, high and low grade kerosines, diesel oil, furnace oil and waxes. Scheduled for completion in December, 1952, the work is being carried on by the refinery staff.

The projects include a tube still distillation unit with atmospheric and vacuum stages designed to handle 3000 barrels crude oil per stream day; a wax extraction plant complete with chillers and presses; a wax sweating plant and bauxite filtration plant for refining the wax; and a wax moulding and packaging plant. In the main the projects will be assembled from plant materials salvaged from various refineries in Burma.

Prior to the Japanese invasion in 1942, crude oil was piped to the Chauk refinery from Rangoon 300 miles distant. Some of the territory through which the pipe line passes now is in Burmese insurgent hands and repairs have been impossible.

After the war a small Still distillation unit with a maximum capacity of 2250 barrels per day of crude was assembled from salvaged materials. This operation gave a 30 percent residue that contains waxy constituents of the crude and has a set point of approximately 108° F. Unsaleable, it has been run to earth pit storage.

Condor Reports Progress On Rho, Italy Project

Condor recently reported that construction on its 27,000-barrel-a-day refinery at Rho, Italy, had begun and would be completed by the end of 1952. Included are a 30,000-barrel atmospheric distillation unit, a 15,000-barrel catalytic cracker, recovery, separation, and purification units, as well as refining and blending plants and an 82-million-gallon storage unit.

The refinery is connected with the central port of Genoa by a 12-inch pipe line, 72 miles long. Petrocarbon, Ltd., is handling a large part of the design.

Rubber Plant Expansion Underway at Baton Rouge

Major expansion plans for its Baton Rouge, La., Paracril synthetic rubber plant have been announced by Naugatuck Chemical Division of the United States Rubber Company. Construction calls for a new administration building, laboratory, gate house as well as new reactors, drying units and other production equipment. New warehousing and latex storage facilities will also be added. The expansion will bring plant capacity to approximately 30 million pounds of Paracril nitrile rubber, Nitrex latex, high styrene latex and high styrene resins annually. Work is expected to begin this month and be completed early next year.

Canadian Petrochemical Firm Will Build Plant

V. G. Bartram, of Montreal, president of Shawinigan Chemicals Limited, has been elected president of B. A.-Shawinigan Limited, the new petrochemical company owned jointly by the British American Oil Company Limited and Shawinigan Chemicals Limited.

The company plans to invest between $3 and $4 million in a plant near the present British American refinery in Montreal East, for the production of phenol and acetone from refinery gases.

The Canadian Kellogg Company Ltd. of Toronto is engineering and building the new plant, which is expected to be in production by late next year.

Vice president of the new company is M. S. Beringer, of Toronto, British American's vice president in charge of manufacturing. Other directors are Dr. R. S. Jane and P. W. Wright, Montreal, vice president and secretary-treasurer respectively of Shawinigan Chemicals, and H. T. O'Neill and R. E. Irwin, Toronto, vice president (finance) and chief chemist respectively of British American. Secretary-treasurer of the new firm is G. S. Herring.

The head office of B. A.-Shawinigan Limited is in the Shawinigan Building, 600 Dorchester Street West, Montreal.

Catalytic Construction Has Contract at El Paso

Catalytic Construction Company will handle construction of Standard Oil Company of Texas' alkylation plant at its El Paso refinery. Construction will start this fall. An item in the July issue, due to error at the source, said that The M. W. Kellogg Company would handle both design and construction whereas its contract calls only for design, engineering and procurement of materials, but does not include construction.

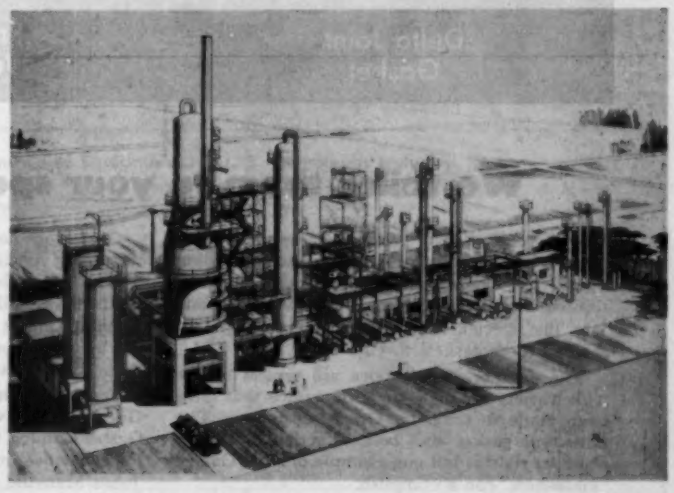
Snyder Gas Plant Makes Initial LPG Shipment

Initial shipments of liquefied petroleum gas products were made late in June from the new Snyder Gasoline Plant in Scurry County, Texas. The plant is operated by Sunray Oil Corporation on behalf of 30 companies and 60 individual co-owners, and it is expected that the plant will produce 50 to 60 carloads, or 450,000 gallons, of products per day. Full plant facilities are operating this month producing propane, butane, iso-butane, and natural gasoline.

Construction of the $8 million natural gas project was begun in October, 1950, and was finished ahead of schedule. The plant will process 70,000 Mcf. of gas daily, according to E. J. Mills, plant superintendent.

Synthetic Ammonia Plant Will Be Built by Shell

A synthetic ammonia plant will be added by Shell Chemical Company to its other petrochemical manufacturing units at Dominquez, Calif., Jan Oostermeyer, president, announced last month. Construction will start this year for late 1952 completion.



NEW EQUIPMENT AT SARNIA—Construction has started on the high-octane gasoline producing equipment for Canadian Oil Companies' new refinery at Sarnia, Ontario. The facilities—including a new Orthoflow Fluid catalytic cracker, a vapor recovery system, catalytic polymerization and a fractionating tower for splitting butane and propane—is being erected by Canadian Kellogg Company, Ltd., subsidiary of The M. W. Kellogg Company, New York.

The two main vessels on the left are the cracker and its fractionator. Further to the right are the vapor recovery towers, and beyond them are hydrogen sulfide removal equipment and the cat poly unit. The light ends splitter is partly concealed by the cracker bubble tower. All units operate off one control room and function in combination without intermediate storage.

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Investment Makes Oil Fourth Largest Industry in the United States

THE U. S. petroleum industry has expended $12.3 billion in capital additions in the five postwar years, increasing crude production and refining facilities by about one-third and boosting gross assets employed to $32.9 billion at the end of 1950. Estimated total expenditures in 1950 of $2450 million for property, plant and equipment, while a little below that of each of the three preceding years, were larger than in any other year up through 1946.

This appraisal of the nation's fourth largest industry, exceeded in terms of capital investment only by agriculture, railroads and combined divisions of the public utility field, was contained in the annual study of Frederick G. Coqueron and Joseph E. Pogue, of the Petroleum department of the Chase National Bank of the City of New York, entitled, "Financial Analysis of Thirty Oil Companies for 1950."

As a result of the substantial capital expenditures of about $12.3 billion since World War II, "the U. S. petroleum industry is well prepared to meet the requirements of the defense preparations in which this country is now engaged," the authors stated. The total outlay in the five-year period was distributed 61.4 percent for crude oil production facilities, 15.8 percent for refining, 10.2 percent for transportation, 10.1 percent for marketing, and 2.5 percent for other facilities.

Utilizing about $33 billion of total gross assets, the petroleum industry of the U. S. is one of the largest and most important segments of the country's economy, according to the authors. It gives direct employment to more than 1.8 million workers, constitutes a large purchaser of a wide range of materials from other industries, and serves practically the entire economy with essential commodities. "Consequently, the well-being of the oil industry is of prime importance to the whole country."

In terms of capital investment, stated Coqueron and Pogue, the petroleum industry is considered the fourth largest in the country. It is exceeded in size only by agriculture, the railroads, and the combined divisions of the public utility field.

Total gross assets employed by the entire petroleum industry in the U. S. was estimated in the report to have amounted to $32,900 million at the end of 1950. The main components of this figure are: 1) $7500 million in current assets, including cash, oil inventories, materials, and supplies; 2) $25,000 million in fixed assets or property, plant, and equipment; and 3) $400 million in the form of investments, advances, and other assets.

The $25,000 million of gross fixed assets, which represents the industry's investment in property, plant, and equipment, is distributed by departments as follows: 55.6 percent in production installations and properties, 13.2 percent in transportation systems, 18.4 percent in refining, 11.6 percent in marketing, and 1.2 percent in other facilities.

Despite the substantial expenditures necessary for the petroleum industry to keep up with the expanding economic activity and the unprecedented level of sales in 1950, the authors noted that one source of capital funds for expansion—earnings—was less than reported for the peak profit year 1948 because of increased costs and taxes. While stating that the record U. S. demand for crude and refined products in 1950 exceeded new supply by an average of 56,000 barrels a day, the report called attention to the continued steady domestic crude prices, which have not kept pace with the spiral of inflation "in spite of higher taxes, wages and material costs."

The detailed study of the financial results of 30 major oil companies, comprising about two-thirds of the domestic industry, showed that the combined net income of the group increased 23.6 percent over 1949 to $1739 million, on a rise of 12.1 percent in gross revenues

Property, Plant, and Equipment of U. S. Petroleum Industry
(Source: Chase National Bank Bulletin, "Financial Analysis of 30 Oil Companies for 1950.")

DEPARTMENT	ESTIMATED EXPENDITURES FOR PROPERTY, PLANT, AND EQUIPMENT IN YEARS 1946-1950 — Million Dollars					5 Yrs., 1946-1950		ESTIMATED INVESTMENT DECEMBER 31, 1950, IN PROPERTY, PLANT AND EQUIPMENT — Gross		Net	
	1946	1947	1948	1949	1950	$ Million	Percent of Total	$ Million	Percent of Total	$ Million	Percent of Total
Production Department	1,100	1,425	1,700	1,650	1,675	7,550	61.4	13,900	55.6	6,725	52.9
*Oil Leases, Wells, Equipment	1,050	1,325	1,550	1,450	1,500	6,875	55.9	12,800	51.2	6,050	47.6
Natural Gasoline Plants	55	50	100	110	75	370	3.0	750	3.0	450	3.5
*†Natural Gas	15	50	50	90	100	305	2.5	350	1.4	225	1.8
Transportation Department	170	310	325	270	175	1,250	10.2	3,300	13.2	1,750	13.8
Crude Oil Pipe Lines	75	130	180	150	125	660	5.4	1,525	6.1	775	6.1
Product Pipe Lines	30	40	30	25	25	150	1.2	325	1.3	200	1.6
Marine	60	125	100	75	15	375	3.0	1,100	4.4	650	5.1
Tank Cars; Motor Trucks	5	15	15	20	10	65	0.5	350	1.4	125	1.0
Refining Department	250	400	600	420	275	1,945	15.8	4,600	18.4	2,300	18.1
Marketing Department	200	300	235	240	275	1,340	10.1	2,900	11.6	1,750	13.8
Others	30	65	100	70	50	315	2.5	300	1.2	175	1.4
Total, All Departments	1,750	2,500	2,950	2,650	2,450	12,300	100.0	25,000	100.0	12,700	100.0

* Expenditures include costs of drilling dry holes.
† Expenditures include those for transportation facilities.

to $15,574 million, while total operating costs and other deductions advanced 8.3 percent to $13,007 million and taxes charged to income bounded up 46.1 percent in 1950 to $1150 million. The latter figure is exclusive of consumer taxes of gasoline and other petroleum products in the amount of $1914 million collected by the companies for government agencies.

Preferred and common cash dividends declared by the group for payment to stockholders totaled $686 million in 1950, which was 39.4 percent of available earnings and was the largest disbursement in the 17-year period, 1934-1950, for which the bank has detailed pertinent data of the 30 companies. The balance of $1053 million of earnings was reinvested in the business or retained.

In 1950, the group obtained funds totaling only $159 million from banks, insurance companies and public investors, compared with a peak of $682 million in 1947 and $641 million in 1949. Of the total raised, $152 million represented borrowings and $7 million sale of common stock. Of the proceeds, 56.6 percent was applied to retirement of existing obligations and 43.4 percent went for acquisition of new assets and working capital. The total cash flow of the 30 companies was $3444 million, of which 89.4 percent was provided by earnings, 4.6 percent derived from the issuance of long-term debt and stock, and 6 percent generated from the sale of assets and other transactions. Of the total disposed, amounting to $3030 million, 65 percent went for capital expenditures and related business investments, 23.9 percent for dividends to stockholders and minority interest, and 11.1 percent for refunding and retirement of long-term debt and preferred stock. The excess of funds provided over those disposed, amounting to $414 million, was added to working capital which, at the end of the year, totaled $3852 million.

Capital expenditures of the 30 companies in 1950 totaled $1,894 million, including $1,667 million of U. S. facilities and $227 million for foreign projects.

Of the total, 63 percent was expended for crude production, 14.8 percent for refining, 8 percent for transportation, 12.3 percent for marketing, and 1.9 percent for other facilities. In addition to the expenditures of $985 million made by the group for domestic crude production facilities, disbursements of $65 million for undeveloped lease rentals and $150 million for exploratory expenses were made and charged to earnings, making a total of $1200 million allocated for exploration and development of U. S. crude oil reserves. The outlay averaged $1.18 for each barrel produced in the U. S. by the 30 companies in 1950, compared with $1.21 a barrel in 1949.

TABLE 1
U. S. Petroleum Demand and Supply Trends
(Barrels Daily)

	DEMAND		PETROLEUM SUPPLY					
	Total for All Oils		Imports		U. S. Natural Gasoline		U. S. Crude Production	
	Volume	5-Year Gain	Volume	5-Year Gain	Volume	5-Year Gain	Volume	5-Year Gain
1935	3,048,000	.....	144,000	.....	105,000	.....	2,730,000	.....
1940	3,961,000	913,000	239,000	95,000	153,000	48,000	3,707,000	977,000
1945	5,238,000	1,277,000	311,000	72,000	307,000	155,000	4,694,000	987,000
1950	6,903,000	1,445,000	847,000	536,000	496,000	189,000	5,405,000	711,000
1955 Est.	8,350,000	1,550,000	1,600,000	753,000	650,000	154,000	6,100,000	695,000
1960 Est.	10,000,000	1,650,000	2,500,000	900,000	800,000	150,000	6,700,000	600,000

TABLE 2
United States Oil Discovery Efficiency Rates

	CRUDE PRODUCTION	CRUDE RESERVES		NEW CRUDE PROVED UP DURING YEAR		
	Million Barrels Yearly	Million Barrels End of Year	Per Barrel Produced	Million Barrels Proved	Per Barrel Produced	Barrels Per Wildcat Completed
Pre-War:						
1937	1,279	15,507	12.1	3,732	2.9	1,705,785
1938	1,214	17,348	14.3	3,054	2.5	1,305,103
1939	1,265	18,483	14.6	2,390	1.9	873,634
1940	1,353	19,024	14.1	1,893	1.4	635,022
1941	1,403	19,589	13.9	1,960	1.4	577,589
Average	1,303	.....	....	2,807	2.0	947,383
Post-War:						
1946	1,733	20,074	12.1	2,658	1.5	636,891
1947	1,857	21,485	11.6	2,445	1.3	494,682
1948	2,016	23,280	11.6	2,873	2.0	620,125
1949	1,840	24,650	13.6	2,188	1.7	470,127
1950	1,972	26,208	12.8	2,563	1.3	330,207
Average	1,884	.....	....	2,970	1.6	491,786
Future Needs:						
1955	2,220	31,164	14.0	4,007	1.8	360,018
1960	2,457	34,396	14.0	4,423	1.8	300,027

The combined world-wide crude oil production of the group averaged 3,669,000 net barrels daily in 1950, an increase of 6.5 percent over 1949. The domestic operations of the 30 companies contributed 2,784,000 net barrels per day, which represented 51.5 percent of the total production of the U. S. The volume of crude oil processed by the domestic and foreign refineries of the group established a new record in 1950, averaging 5,729,000 barrels a day, an increase of 9.3 percent over 1949. The domestic facilities of the group ran to stills 4,943,000 barrels daily, or about 86.1 percent of the total throughput of all refineries operating in the U. S.

Discovery

CONTINUED FROM PAGE 50

mately 11,000 wildcats per year by that time. By 1960 the annual completion of wildcats could reach approximately 14,700 per year.

Growth in the number of dry holes completed has boosted the number of failures drilled per million barrels of production to 7½ dry holes in 1950, in contrast with a little more than five dry holes per million barrels produced in prewar times. This increase in dry holes will likely continue, since large numbers of wildcats cannot be drilled without a corresponding gain in failures. Present trends indicate that nine dry holes may be drilled per million barrels of production, or approximately 19,000 per year within five years. Wildcat drilling has steadily comprised an increasing portion of drilling activity. In 1950, wildcats comprised 18.5 percent of all wells completed—to compare with 6.8 percent in 1937.

Dry hole operations accounted for only 20 percent of drilling operation in 1937, but grew to 35 percent in 1950. Recent rates indicate that approximately 43 percent of all wells may be failures by 1960. The prospect of drilling a larger number of wells, including more wildcats and dry holes, confronts the industry with a terrific financial problem. There is an imperative need for increasing the incentives for oil exploration and development. Such incentives might include absolute assurance of the 27½ percent depletion allowance and the right to expense intangible drilling and development costs.

The figures used represent the projection of present trends and are based on the ability of the U. S. to import a minimum of 1.6 million barrels per day by 1955 and 2.5 million barrels daily by 1960. Any failure of U. S. production to reach the levels indicated would require additional importation of foreign oil.

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1877 *Another founding member was first to establish a research and control laboratory.*

1892 *First in world to manufacture cupro-nickel alloy tubes.*

1898 *First in the U.S. to manufacture Admiralty alloy tubes.*

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1930 *First in the U.S. to manufacture seamless tubes extruded from solid billet.*

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1933 *First to demonstrate that arsenic in proper amount added to admiralty metal and aluminum brass will inhibit dezincification corrosion —and that the optimum arsenic content is 0.04%.*

1939 *First to prove that a proper amount of iron added to cupro-nickels of low nickel content will produce relatively low-cost condenser and heat-transfer tube alloys that are highly resistant to impingement and pitting corrosion from sea water. This research* resulted in a 10% nickel alloy, Cupro-Nickel 754.†*

*See ASTM Proceedings, Vol. 45, 1945—591-612
†U. S. Pat. 2,074,604

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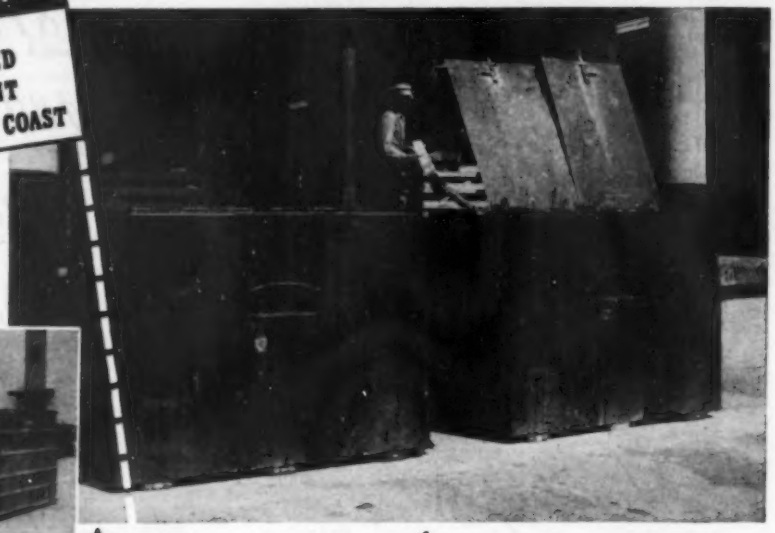

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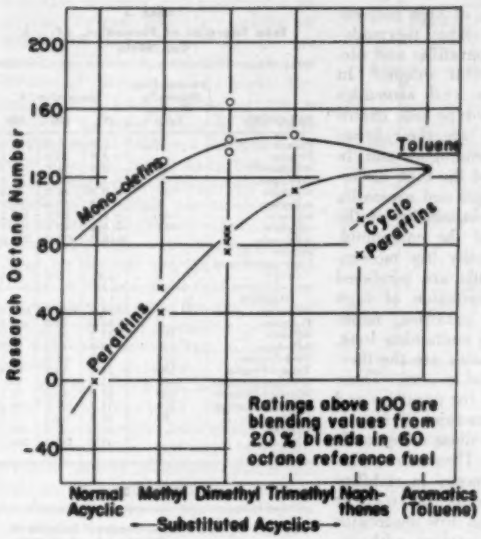
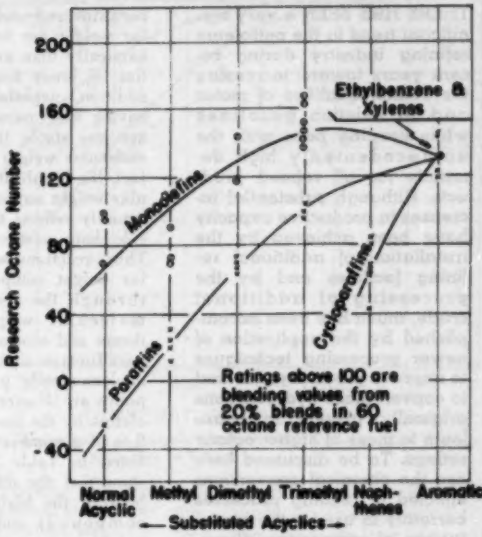


Structure Of The C_7 Hydrocarbons

Figure 1. Effect of Structure on Octane Quality of the C_7 Hydrocarbons.



Structure Of The C_8 Hydrocarbons

Figure 2. Effect of Structure on Octane Quality of the C_8 Hydrocarbons.

Production of High-Octane Gasoline Components

PETROLEUM REFINER
AUGUST, 1951

PART I

A. A. DRAEGER, G. T. GWIN, C. J. G. LEESEMANN, M. R. MORROW
Humble Oil & Refining Company, Baytown, Texas

A REVIEW of the octane numbers of the major types of hydrocarbons reveals that by far the most desirable components of gasolines are branched-chain paraffins, branched-chain olefins, and aromatics; it is not surprising that the newer processes developed have been based on the more selective production of hydrocarbon components of these types. API data[1] presented graphically as Figures 1 and 2 illustrate the significantly higher octane quality of the above three types of hydrocarbons in comparison with less branchy paraffins, olefins, and naphthenes. Figure 3 shows the relative octane qualities of paraffins of different molecular weights, illustrating not only that octane number increases with increasing branchiness of the carbon skeleton of the molecule but also that octane number decreases (for a given degree of branchiness) with increasing molecular weight.[1] These conclusions are based on unleaded Research octane numbers (ASTM D-908-47T), but the same general conclusions can be reached from a study of data obtained by other methods of knock rating and with samples containing tetraethyl lead (TEL). The advantage of olefins over the corresponding paraffins is reduced, however, for samples containing TEL, and the extensive use of olefins in aviation type fuels is not desirable because of other fuel requirements such as storage stability. It should be pointed out that the Research octane numbers shown are blending octane numbers of the individual components in 20 per cent concentration in 60 octane number reference fuel (saturated).

The three most important methods of increasing supplies and quality of gasolines, in addition to straight-run distillation, comprise: 1) the thermal or catalytic decomposition ("cracking") of materials boiling above the gasoline boiling range; 2) the condensation, polymerization, or alkylation of compounds lighter (lower boiling) than those present in gasolines; and 3) the rearrangement or structural alteration of compounds within the gasoline boiling range.

TABLE 1
Percent by Weight of Hydrocarbon Types in Crude

50 Percent Distillation Point of Fractions, °F.	"Conventional" Nomenclature			Waterman Type Analysis Nomenclature		
	Paraffins	Naphthenes	Aromatics	Paraffin Chains	Naphthene Rings	Aromatic Rings
280	65	30	5	77	20	3
450	60	30	10	75	18	6
600	35	50	15	75	17	8
780	20	65	15	76	16	8

Theoretical Considerations

Thermal and Catalytic Cracking

In the cracking of high molecular weight components of crude, the reactions of paraffins are of primary importance, whereas the reactions of naphthenic and aromatic rings are of

THERE HAS BEEN a very significant trend in the petroleum refining industry during recent years toward increasing the octane qualities of motor and of aviation gasolines while keeping pace with the unprecedentedly high demands for all refined products. Although substantial increases in productive capacity have been achieved by the installation of additional refining facilities and by the processing of additional crude, much has been accomplished by the application of newer processing techniques to improve product yields and to convert those hydrocarbons originally present in petroleum to those of higher octane ratings. To be discussed here are the chemical conversions effected in refining processes currently in use for the manufacture of components of motor and of aviation gasolines, especially the behavior of various hydrocarbon types rather than of individual compounds because of the complex composition of petroleum fractions. To show the significance in refining operations of the processes described, calculations are presented to show the effect of the progressive application of various processes on the yield and octane quality of motor and aviation fuels for a given refinery situation.

Part I discusses the theoretical considerations involved in producing high-octane gasoline components. Parts II and III will appear.

only secondary importance because of the high stability of these ring compounds. Although the concentration of paraffins, as conventionally defined, decreases markedly with increases in boiling point of fractions from crude, this indicated decrease is misleading since the total paraffin content of fractions from crude (including paraffinic side chains on high boiling ring compounds) is essentially constant as shown by conventional and Waterman[2] type analyses in Table 1.

Since olefins are among the primary products of paraffin cracking, their reactions are quite important in considering the theoretical aspects of the cracking process. The basis for the cracking process lies in the fact that paraffins and olefins of high molecular weight are less stable thermodynamically than are paraffins and olefins of lower molecular weight.[3] In addition, naphthenes and aromatics having long, paraffin-type side chains are less stable than are their lower molecular weight homologues and, in fact, the instability of the high molecular weight naphthenes and aromatics actually reflects the instability of the side-chain portion of the compound. Thus, reactions whereby low molecular weight compounds are produced through the decomposition of high molecular weight paraffins, naphthenes and aromatics containing long, paraffin-type side chains are the thermodynamically probable ones. These points are illustrated for paraffins and olefins by the free energies of formation of a number of these compounds listed in Table 2. These data also show that the differences in stability between the high molecular weight compounds and the low molecular weight compounds increase with increasing temperature, emphasizing the desirability of conducting cracking operations at high temperatures.

For paraffins of the same molecular weight, normal compounds are more stable at high temperatures (above about 600°F.) and less stable at low temperatures than the corresponding isomeric paraffins as indicated by the data[4] shown in Table 3; these data also indicate that the thermodynamically probable reaction in cracking is decomposition of the paraffins into their component elements. Actually, reaction rates are such that the major reaction is carbon-to-carbon bond rupture, producing a paraffin and an olefin, each of which is potentially

TABLE 2
Free Energies of Formation, ΔF_f°, k Cal./Mole

	Research Clear Octane No. Blending Value	Temperature °K		
PARAFFINS		298	600	900
Ethane	...	— 7.9	+ 6.0	+15.9
Propane	...	— 5.6	15.5	30.4
n-Butane	113	— 3.8	24.6	44.5
n-Pentane	62	— 2.0	33.8	58.6
n-Hexane	25	+ 0.05	43.2	73.2
n-Heptane	0	+ 2.1	52.6	87.7
n-Octane	—20	+ 4.1	62.0	102.2
n-Decane	—41	+ 8.2	80.9	131.1
n-Eicosane	...	+28.7	175.2	276.0
Increase in ΔF_f° per Carbon atom (Avg.)	...	2.0	9.3	14.4
OLEFINS				
Ethylene	...	+16.3	+30.9	+24.5
Propylene	...	15.0	26.5	34.6
1-Butene	144	17.2	35.8	49.0
1-Pentene	115	16.8	44.6	62.8
Cis-2-Pentene	154	17.2	43.5	62.1
Trans-2-Pentene	150	16.6	42.9	61.4
2-Methyl-1-butene	146	15.5	41.9	60.4
3-Methyl-1-butene	129	17.9	44.6	63.3
2-Methyl-2-butene	170	14.3	41.0	59.9
1-Hexene	97	20.8	54.1	77.2
1-Decene	...	29.0	91.8	135.2
1-Eicosene	...	49.5	186.1	280.1

TABLE 3

	Free Energies of Formation of Hexanes, ΔF_f°, k cal/mole			
	300 °K.	600 °K.	700 °K.	900 °K.
n-Hexane	0.3	+43.2	+58.1	+73.2
2-Methylpentane	—0.9	42.6	57.7	73.0
3-Methylpentane	—0.3	43.1	58.2	73.3
2,3-Dimethylbutane	—2.1	42.8	58.4	74.1
2,3-Dimethylbutane	—0.7	43.7	59.2	74.7

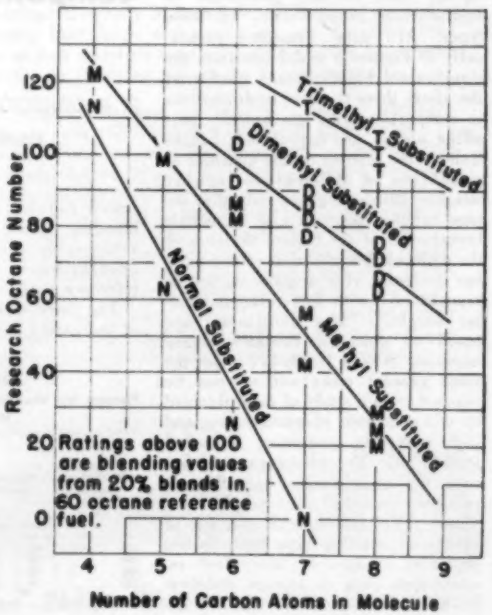


Figure 3. Octane Quality of Various Paraffinic Hydrocarbons.

available to enter into subsequent reactions. Several possible cracking reactions of hexane and butane are shown in Table 4, and, although production of methane and an olefin containing one less carbon atom is indicated as most probable, the rates of the several reactions indicated are such that the carbon-to-carbon bond rupture occurs most frequently in the middle of the chain and to an appreciable extent at various other carbon-to-carbon bonds within the chain. Data[5] on thermal cracking of normal butane in Table 5 show that increasing temperature increases the quantities of products obtained through rupture of the carbon-to-carbon chain at near the center of the molecule.

From the products obtained, it would be expected that pressure should have a significant effect on the cracking reaction and that increased pressure should materially retard the reaction. However, in actual practice, the decomposition of the paraffins is essentially independent of pressure and the uncatalyzed reaction does not proceed to thermodynamic equilibrium in reasonable periods of time. From a practical standpoint, therefore, increasing pressure in a given processing unit when charging a given volume of cracking stock materially increases the length of time that the cracking stock is subjected to cracking temperatures but does not materially decrease the rate of cracking.

The cracking of paraffins to yield an olefin and a paraffin of lower molecular weight can be expressed by the well known mono-molecular reaction rate equation

$$\frac{dx}{dt} = k(c - a)$$

in which k is the reaction velocity constant, t the reaction time, c the original concentration of the component being cracked and a the percentage of the component cracked in time t. It has been mentioned previously that the higher molecular weight paraffins are less stable than are the lower molecular weight paraffins. Not only is this true from a thermodynamic standpoint, but also the rates of decomposition of the higher molecular weight paraffins are greater than those of the lower molecular weight compounds, as is brought out by the comparison in Table 6 of the rate constants for the decomposition of several paraffins.[6]

In the thermal cracking of paraffins, relatively little isomerization of the products formed occurs, and in this respect thermal cracking differs materially from catalytic cracking. This statement cannot be made without proper qualification, inasmuch as the utilization of different catalysts may give quite different results and the composition of the products from catalytic cracking are dependent not only upon the type of catalyst employed but also upon the cracking conditions imposed in the reaction. In the conventional fluid catalytic cracking operation, in which a silica on alumina catalyst is employed, large amounts of paraffins and olefins of lower molecular weight than the feed stock are produced and a substantial amount of isomerization of the paraffins and olefins so produced occurs in the reaction zone. Thus, since the isomeric paraffins and olefins are of higher octane quality than are the normal, or straight chain, paraffins and olefins, a substantial improvement in octane quality of gasoline components over that obtainable with conventional thermal cracking is possible by the catalytic process.

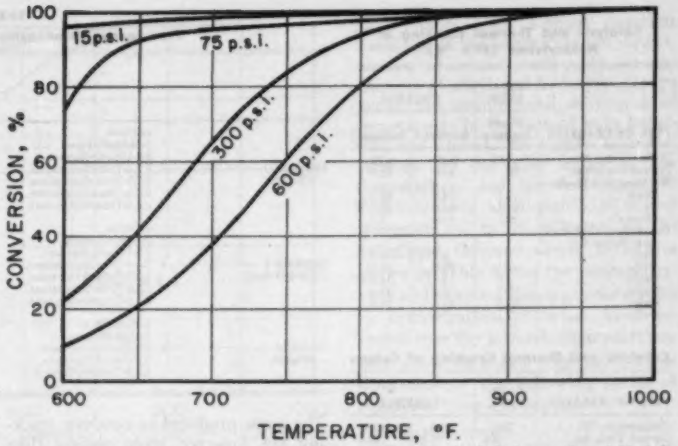


Figure 4. Thermodynamic Temperature and Pressure Effects in the Dehydrogenation of Methylcyclohexane to Toluene.

TABLE 4
Possible Reactions in Thermal Cracking of Hexane and Butane

		ΔF_T° (700 °K) k cal/mole
nC_6H_{14}	$nC_6H_{12} - 1 + H_2$	+7.8
nC_6H_{14}	$nC_5H_{10} - 1 + CH_4$	−7.8
nC_6H_{14}	$nC_4H_8 - 1 + C_2H_6$	−4.8
nC_6H_{14}	$C_3H_6 + C_3H_8$	−4.6
nC_6H_{14}	$C_2H_4 + C_4H_{10}$	−1.0
nC_4H_{10}	$n\text{-}C_4H_8 - 1 + H_2$	+7.9
nC_4H_{10}	$C_3H_6 + CH_4$	−6.9
nC_4H_{10}	$C_2H_6 + C_2H_4$	−0.9

TABLE 5
Thermal Cracking of n-Butane

	Moles Produced per 100 Moles of n-Butane Cracked		
Temperature, °K	$CH_4 + C_3H_6$	$C_2H_6 + C_2H_4$	$C_4H_8 + H_2$
848	60	30	10
873	55	40	5
903*	54	46	5

* Carbon-forming and polymerization reactions appreciable.

TABLE 6
Velocity Constants for Decomposition of Paraffins

	k, at 854 °K
Methane	3.3×10^{-9}
Ethane	8×10^{-9} (888 °K)
Propane	1.5×10^{-5}
n-Butane	4.8×10^{-5}
i-Butane	4.8×10^{-5}
n-Pentane	5.7×10^{-5}
i-Pentane	6.5×10^{-5}
n-Hexane	15×10^{-5}

While the reactions of paraffins and olefins are of primary importance in the thermal cracking of petroleum fractions, the ultimate reactions of the aromatic and naphthene ring compounds originally present in the petroleum fractions become quite important because of the substantial increase in cracking rates. In thermal cracking, the rupture of paraffin side chains attached to naphthenic and aromatic ring compounds does not proceed to any appreciable extent, and, therefore, very few of the compounds containing the naphthene or aromatic rings are sufficiently reduced in molecular weight to appear in the gasoline boiling range of the product. In catalytic cracking, however, the increased rate of reaction of the materials originally present and the high rate of reaction of the products obtained from the primary reactions results in the successive reaction of high molecular weight naphthenic and aromatic ring compounds so that large amounts of gasoline boiling range naphthenes and aromatics are present in the product from catalytic cracking. A review of the octane qualities of compounds of these types shows that these materials contribute greatly to the higher octane quality of gasolines produced in catalytic cracking.

Since olefins are one of the princi-

TABLE 7

Catalytic and Thermal Cracking of N-Butylenes (873 °K)

TYPE OF CRACKING	CATALYTIC	THERMAL	
	Mixed Butylenes	Butylene-1	Butylene-2
Contact Time, Sec.	1.05	ca.30	ca.30
Percent Converted	32	45.0	34.2
Wt. Percent of Charge:			
Below C_4	15.7	32.1	29.0
C_4	71.6	55.0	65.8
Above C_4	12.7	12.9	5.2
Gas Analysis, Vol. Percent, Below C_4:			
H_2	5.1	2.7	10.2
C_1H_6	12.1	37.5	31.8
C_2H_4	1.6	14.8	14.8
C_2H_6	6.3	8.5	13.6
C_3H_6	67.8	35.2	29.6
C_3H_8	7.1	....	....

Catalytic and Thermal Cracking of Cetene

TYPE OF CRACKING	CATALYTIC	THERMAL	
Temperature, °K	723	723	823
Contact Time, Sec.	5.4	75.0	50.5
Percent Converted	97	5.0	69.7
Wt. Percent of Charge:			
Gas	21.2	0.3	37.5
Liquid Below C_{16}	62.3	4.7	32.2
Remainder	16.5	95.0	30.3
Gas Analysis, Vol. Percent:			
H_2	2.8	0	5
Olefins	68.1	29	65
Saturates	29.1	71	30
Mol. Wt. of Gas	48	....	31

pal reaction products in the cracking of paraffins, their behavior during the cracking reaction is important. The principal reactions of olefins are polymerization and depolymerization and, under the usual high temperature conditions of cracking, the depolymerization reaction predominates.[7]

In the catalytic cracking of olefins, a very large amount of isomerization of products occurs as opposed to the thermal cracking operation.[8] Further, in catalytic cracking, larger fragments of the original material and less degradation products such as methane are produced than in thermal cracking.

Figure 5. Thermodynamic Effect of Added Hydrogen upon Conversion of Methylcyclohexane to Toluene.

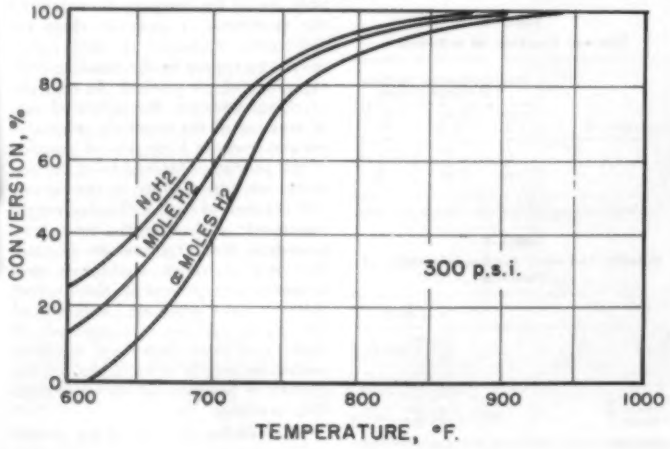


TABLE 8

Free Energy Relationships in Isobutane Alkylation

		$\Delta F_f°$ (298.2 °K) k cal./Mol	Research Clear Octane Number Blending Values of Products
Isobutane + 1-Butene →	n-Octane	−8.8	−20
	2-Methylheptane	−9.9	13
	2,5-Dimethylhexane	−10.4	56
	2,2,4-Trimethylpentane	−9.8	100
	2,2,3-Trimethylpentane	−8.8	105
	2,3,3-Trimethylpentane	−8.4	100
	2,3,4-Trimethylpentane	−8.6	97
Isobutane + Cis-2-Butene →	n-Octane	−7.6	−20
	2-Methylheptane	−8.7	13
	2,5-Dimethylhexane	−9.2	56
	2,2,4-Trimethylpentane	−8.6	100
	2,2,3-Trimethylpentane	−7.7	105
	2,3,3-Trimethylpentane	−7.2	100
	2,3,4-Trimethylpentane	−7.4	97
Isobutane + Propene →	n-Heptane	−8.6	0
	2-Methylhexane	−9.7	41
	2,4-Dimethylpentane	−10.0	77
	2,3-Dimethylpentane	−10.5	87
	2,2,3-Trimethylbutane	−9.9	113

The gases produced in catalytic cracking are, however, more olefinic than those produced in thermal cracking. The higher saturation of the thermal gases probably is the result of preferential production of methane and ethane (especially methane) rather than of saturation of olefins produced. The higher unsaturation of light fractions from catalytic cracking as compared to thermal cracking is illustrated by the data[9] presented in Table 7 on cracking of butylenes and cetene.

Polymerization

Light hydrocarbons derived from cracking are extensively converted into gasoline boiling range components by polymerization-type reactions. The olefin polymerization reaction has a negative free energy at low temperatures, and catalytic polymerization is conducted at relatively low temperatures and moderate pressures. The imposition of high pressures allows the non-catalytic polymerization of olefins at high temperatures. In the thermal polymerization process, light paraffins (or paraffins and olefins) are subjected to high temperature and high pressure conditions under which the paraffins are cracked principally to olefins, and the olefins are polymerized to higher molecular weight olefins in the gasoline boiling range.

Alkylation

A particularly important method of producing gasoline boiling-range components is the alkylation of isoparaffins with olefins. By means of this reaction, gasoline boiling range isoparaffins are produced through reaction of a light isoparaffin and a light olefin in the presence of a catalyst. At low temperatures, the free energy relationships are extremely favorable for the production of the high molecular weight paraffins as is exemplified by the data[10] tabulated in Table 8. The alkylation reaction is quite selective in that only minor amounts of materials other than isomers of the reactants combined in stoichiometric proportions are produced through dis-

TABLE 9

Analyses of Alkylates, Volume Percent of Components in Depentanized Alkylates

Olefin Charge	MIXED BUTYLENES			MIXED PENTYLENES		
Catalyst	H_2SO_4	H_2SO_4	HF	H_2SO_4	H_2SO_4	HF
Component in Depentanized Alkylate:						
Hexanes	8.8	2.1	2.1	4.9	3.2	1.6
Heptanes	7.0	2.1	4.5	3.2	2.4	3.3
2,2,4-Trimethylpentane	26.7	34.5	41.7	17.2	21.7	34.2
2,2,3-Trimethylpentane	1.3	2.0	2.9	0.8	0.7	0.7
2,3,3-Trimethylpentane	13.5	35.2	10.0	7.1	9.5	4.2
2,3,4-Trimethylpentane	14.2	24.0	9.4	9.4	9.4	8.4
Dimethylhexanes	11.2	5.8	19.6	4.8	4.6	5.1
Isomeric Nonanes	6.4	3.3	3.4	40.2	36.0	41.0
Heavier	12.8		6.4	15.4	12.5	14.5

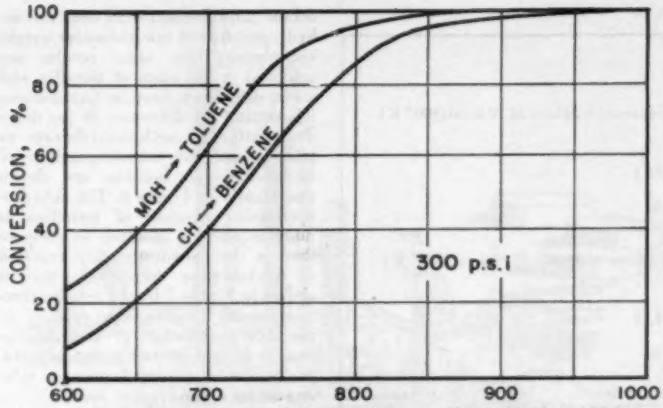


Figure 6. Thermodynamic Comparison of the Dehydrogenation of Methylcyclohexane to Toluene and Cyclohexane to Benzene.

proportionation reactions. Concentrated sulfuric acid is one of the most widely used catalysts for this operation; hydrofluoric acid is also an important catalyst and differs from sulfuric acid in that it enables the production of somewhat different types of products. The compositions of the products obtained in the sulfuric acid and hydrofluoric acid alkylation of isobutane with different olefins are shown in Table 9.[11] It will be observed that a number of compounds are present in the alkylate product whose structure does not conform to what might be expected from the direct joining of an olefin to isobutane. For example, 2,3,4-trimethylpentane and 2,3,3-trimethylpentane, both of which are found in alkylates, cannot be formed by a simple combination of butylenes with isobutane. There have been a number of theories that have been advanced to explain the mechanisms whereby compounds of this type are produced in the alkylation reaction, and although none of the theories give a completely satisfactory explanation, the carbonium ion theory[12] offers probably the best over-all explanation for the reactions that occur. In alkylation, the formation of the several types of hydrocarbons produced can be adequately explained on the basis of the formation of a tertiary butyl carbonium ion from isobutane, and the combination of this carbonium ion with an olefin to form a carbonium ion of higher molecular weight which may be altered in structure by the shifting of methyl groups and bonding electrons, followed by the seizure of a proton with two bonding electrons to form a paraffin.

Isomerization

Rearrangement reactions involving materials present in the gasoline boiling range fractions from either crude petroleum or the products of cracking offer excellent methods of obtaining high octane number quality gasoline components. One of the more important, and the only true rearrangement process that is of significance, is structural isomerization. In the case of the isomerization of paraffins, the over-all reaction results in an exchange of alkyl and hydrogen groups, the mechanism of which cannot be specifically defined but which may be accomplished through loosening of the interatomic bonds so that atoms and groups of atoms shift to a more thermodynamically stable form without complete breakage of the bonds.[13] In the isomerization of olefins, not only do exchanges of alkyl and hydrogen groups occur, but double bond shifting is of importance. In the case of both paraffins and olefins, the highly branched isomers are the most stable at low temperatures and the less branched structures are most stable at higher temperatures, as is reflected by the calculated thermodynamic equilibria shown in Table 10 for the various hexanes and hexenes. Reaction rate studies in isomerization processes have revealed that the isomerization reactions take place in a step-wise manner, as illustrated by the following series of equations[14] for the hexanes:

N-Hexane ⇄ 2-Methylpentane ⇄ 3-Methylpentane

2,3-Dimethylbutane ⇄ 2,2-Dimethylbutane

All of the above reactions do not take place with equal ease. The equilibrium between 2-methylpentane and 3-methylpentane is established very rapidly while 2,2-dimethylbutane is extremely difficult to form, but once formed, is extremely stable under isomerization conditions. The rate determining step in the formation of 2,2-dimethylbutane is in going from 2,3-dimethylbutane, while the rate determining step in the formation of the 2,3-dimethylbutane is in going from normal hexane to the methylpentanes. Deviations from thermodynamic equilibrium may be quite large as a result of differences in reac-

TABLE 10

Vapor Phase Thermodynamic Equilibrium Concentrations of the Hexanes at Different Temperatures (Mole Fractions)

	Research Clear Octane Blending Values	Temperature, °K		
		298	400	800
N-Hexane	25	0.014	0.060	0.249
2-Methylpentane	73	0.099	0.200	0.287
3-Methylpentane	74	0.036	0.099	0.230
2,2-Dimethylbutane	94*	0.775	0.523	0.139
2,3-Dimethylbutane	96	0.076	0.109	0.096
Calculated Research Clear Octane Number	..	88.7	82.7	66.3

Vapor Phase Thermodynamic Equilibrium Concentrations of the Hexenes at Different Temperatures (Mole Fractions)

	Research Clear Octane Blending Values	Temperature, °K		
		298	400	800
1-Hexene	97	0.0002	0.0014	0.0241
Cis-2-Hexene	134	0.0027	0.0104	0.0451
Trans-2-Hexene	134†	0.0060	0.0251	0.0746
Cis-3-Hexene	137	0.0012	0.0043	0.0187
Trans-3-Hexene	137†	0.0046	0.0116	0.0374
2-Methyl-1-Pentene	135‡	0.0470	0.0778	0.1390
3-Methyl-1-Pentene	113	0.0004	0.0030	0.0236
4-Methyl-1-Pentene	135‡	0.0008	0.0030	0.0187
2-Methyl-2-Pentene	150	0.3217	0.2735	0.1490
Cis-3-Methyl-2-Pentene	135‡	0.1063	0.1386	0.0960
Trans-3-Methyl-2-Pentene	135‡	0.1639	0.1878	0.1490
Cis-4-Methyl-2-Pentene	130	0.0100	0.0172	0.0531
Trans-4-Methyl-2-Pentene	130†	0.0288	0.0368	0.0481
2-Ethyl-1-Butene	143	0.0062	0.0172	0.0451
2,3-Dimethyl-1-Butene	148	0.0612	0.0533	0.0543
3,3-Dimethyl-1-Butene	127	0.0034	0.0043	0.0047
2,3-Dimethyl-2-Butene	165	0.2373	0.1490	0.0574
Calculated Research Clear Octane Number	...	155.3	149.2	139.7

* Straight Rating. † Octane values for mixed isomers. ‡ Estimated.

Exhibit A

Hydroforming

$$\text{Cyclohexane} \xrightarrow[H_2]{\text{Catalyst}} \text{Benzene} + 3H_2 - 52.70 \text{ k cal}(800^\circ \text{ K})$$

Theoretical Volume % Yield	100	82.3
Research Clear Octane Number	110	99

$$\text{Methylcyclohexane} \xrightarrow[H_2]{\text{Catalyst}} \text{Toluene} + 3H_2 - 51.50 \text{ k cal}(800^\circ \text{ K})$$

Theoretical Volume % Yield	100	83.4
Research Clear Octane Number	104	124

$$\text{Trans-1,3 Dimethylcyclohexane} \xrightarrow[H_2]{\text{Catalyst}} \text{M-Xylene} + 3H_2 - 49.30 \text{ k cal}(800^\circ \text{ K})$$

Theoretical Volume % Yield	100	84.2
Research Clear Octane Number	85	145

Dehydrocyclization

$$\text{N-Heptane} \xrightarrow[H_2]{\text{Catalyst}} \text{Toluene} + 4H_2 - 60.34 \text{ k cal}(800^\circ \text{ K})$$

Theoretical Volume % Yield	100	72.7
Research Clear Octane Number	0	124

tion rates such as are described above.

Dehydrogenation and Dehydrocyclization

Dehydrogenation (hydroforming) of cyclohexane derivatives to the corresponding aromatics and the dehydrocyclization of paraffins and olefins to aromatics are important combination dehydrogenation-rearrangement processes for increasing the octane quality of gasoline boiling-range components. This increase in octane rating is, however, achieved at the expense of a substantial reduction in volume. Both the hydroforming and dehydrocyclization reactions are highly endothermic and the production of aromatics is favored at high temperatures. The principal reactions involved may be illustrated by the equations contained in Exhibit A.

The hydroforming and dehydrocyclization reactions are carried out in the vapor phase at low-to-moderate operating pressures. Figure 4 shows the calculated relationship between conversion and temperature at several different pressure levels for the dehydrogenation of methylcyclohexane to toluene in the absence of diluents while Figure 5 shows the effect of hydrogen diluent on conversion at a pressure of 300 psia for the same reaction. The effect of adding hydrogen (employed principally to retard catalyst carbonization) is of importance at lower temperatures but is practically negligible at higher temperatures. The dehydrogenation of high molecular weight naphthenes proceeds more readily and results in a much greater octane improvement than does the dehydrogenation of low molecular weight naphthenes; the same results are achieved in the cases of paraffin and olefin dehydrocyclization. Calculations illustrating the difference in the dehydrogenation of methylcyclohexane to toluene and the dehydrogenation of cyclohexane to benzene are shown graphically in Figure 6. The dehydrocyclization reaction of paraffins is more sensitive to increases in pressure than is the dehydrogenation reaction of cyclohexane derivatives; this is shown in Figure 7 by the relative thermodynamic relationships existing in the dehydrogenation of methylcyclohexane to toluene and in the dehydrocyclization of normal heptane to toluene at two temperature levels.

End of Part I. Parts II and III will appear in early issues.

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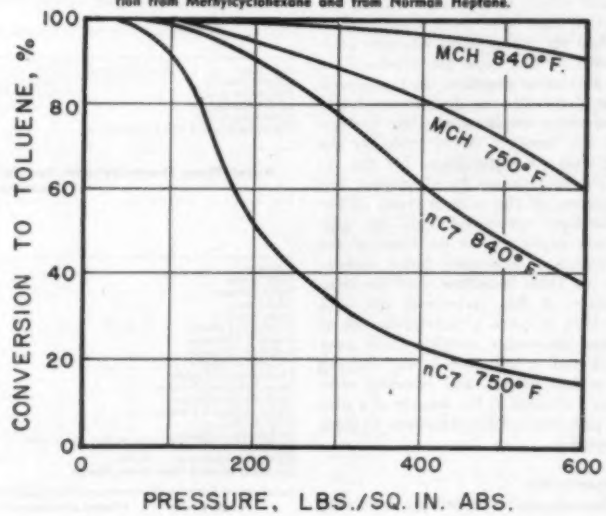
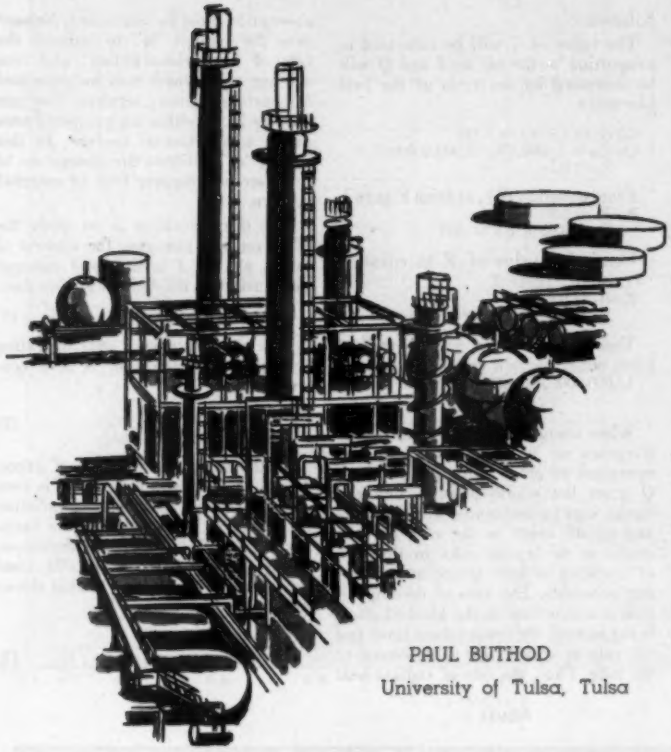
Figure 7. Thermodynamic Comparison of Toluene Formation from Methylcyclohexane and from Normal Heptane.





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Furnace Operation Variables For Process Plant Heaters

SOLUTIONS to a number of problems commonly encountered in the operation of process plant heaters are demonstrated in this article by means of illustrative examples. The author, well known for his work in the field of process design, prepared this material for presentation at the second annual Process Heating Seminar of the John Zink Company which was held in Tulsa on May 26, 1951.

THE rate of radiant heating in a refinery pipestill has been studied by several investigators.[1,2,3] Wilson, Lobo and Hottel,[1] developed the following formula which has been used extensively for pipestill design and operation.

$$R = \frac{1}{1 + \frac{G\sqrt{Q/a\,A_{cp}}}{4200}} \qquad (1)$$

Where, R is the fraction of the total heat liberated in the furnace that is absorbed by the tubes in the radiant section.
G is the number of pounds of air supplied per pound of fuel burned.
Q is the total net heat (above 60° F.) liberated in the flame.
A_{cp} is the area of furnace wall that has tubes mounted on it.
a is a factor to convert A_{cp} to effective radiant absorption surface.

Lobo and Evans[2] derived a method based on radiation theory and backed by experimental data. This method shows a better correlation with actual practice than the equation of Wilson, Lobo and Hottel—especially on furnaces of unusual shape or with fuels not commonly used. The improvement is not so marked when dealing with a standard type installation.

The purpose of this article is to develop a method of studying how the changing of various process variables will affect the operation of an existing furnace. The study will be confined primarily to the radiant section of the furnace but with a few generalizations added about the effect on the convection transfer. Since the method of Wilson, Lobo and Hottel is more convenient to use and for changes in operation would probably lead to results nearly as accurate as Lobo and Evans, their method will be used.

The first problem to be considered is the effect of excess air. How will changing the excess air used in the burner change the heat absorption characteristics of the radiant section? In terms of the symbols used in equation (1), this means to study the effect on R of any change in G.

The subscript 1 will be used to denote existing operating conditions of the furnace and the subscript 2 will be used to signify conditions under a new set of operating variables. Equation (2) below is written for present operating conditions, and equation (3) shows a new set of conditions where the excess air has been changed.

$$R_1 = \frac{1}{1 + \frac{G_1\sqrt{Q/a\,A_{cp}}}{4200}} \qquad (2)$$

$$R_2 = \frac{1}{1 + \frac{G_2\sqrt{Q/a\,A_{cp}}}{4200}} \qquad (3)$$

Now if equation (3) is divided by equation (2) and it is noted that

$$\sqrt{Q/a\,A_{cp}} = 4200\,(1 - R_1)/R_1G_1$$

the following relationship between R and G is obtained.

$$\frac{R_2}{R_1} = \frac{1}{R_1 + (1 - R_1)\frac{G_2}{G_1}} \qquad (4)$$

Thus, if the initial percent absorbed in the radiant section is known together with the air fuel ratio, it is possible to calculate the percent radiant absorption under any conditions of air fuel ratio. Equation (4) is presented graphically in Figure 1. If the symbol e is used to denote percent excess air expressed as a decimal, then

$$G_2/G_1 = (1 + e_2)/(1 + e_1)$$

The next problem will be to study the effect of changing the amount of

heat liberation in an existing furnace. In terms of the symbols of equation (1), this means to study the effect on R of changing Q. By means of methods similar to those above, the following equation is developed.

$$\frac{R_2}{R_1} = \frac{1}{R_1 + (1 - R_1)\sqrt{\frac{Q_2}{Q_1}}} \qquad (5)$$

In this case, if the initial percent absorbed in the radiant section is known, together with the total net heat liberation, any new percent radiant absorption for a new heat input may be determined by equation (5). Equation (5) is presented graphically in Figure 2.

If both G and Q are changed simultaneously, equations (4) and (5) must both be used.

Example 1

A furnace has a heat liberation of 10,000,000 Btu. per hour, using 30 percent excess air. Under these conditions it is found that 50 percent of the heat liberated goes into the radiant tubes. It is proposed to increase the heat liberation to 13,000,000 and the excess air to 50 percent. How much heat will be received by the radiant tubes under these new conditions?

Solution:

The value of G will be increased in proportion to the air used and Q will be increased by the ratio of the heat liberation.

$G_2/G_1 = 1.5/1.3 = 1.155$
$Q_2/Q_1 = 13{,}000{,}000/10{,}000{,}000 = 1.3$
$R_1 = 0.5$

From equation (4), or from Figure 1,
$R_2/R_1 = 0.93$
$R_2 = 0.93 \times 0.5 = .465$

Using this value of R in equation (5), or in Figure 2,
$R_2/R_1 = 0.93$
$R_2 = 0.93 \times 0.465 = 0.432$

The heat absorbed by the radiant tubes under the new conditions will be,
$13{,}000{,}000. \times 0.432 = 5{,}620{,}000.$ Btu. per hour.

When using equation (1) for design purposes or in comparing with the operation of other stills, neither R or Q gives the whole picture. Refinery stocks tend to decompose upon heating and go off color in the case of lube stocks or to deposit coke in the case of cracking or high temperature heating processes. The rate of decomposition is a function of the kind of stock being heated, the temperature level and the rate at which heat is delivered to the tube. Thus, the rate of radiant heat absorption must be controlled. Nelson[4] uses the symbol "q" to indicate the rate of heat absorption, and lists average rates which may be permitted for various refinery services. The rate may be based either on projected area or on total external surface. In this paper, "q" will have the dimensions of Btu. per hour-square foot of external surface.

The third problem is to study the effect on q of changing the amount of excess air. If A is the total external tube surface in the radiant section then,

$$qA = RQ \qquad (6)$$

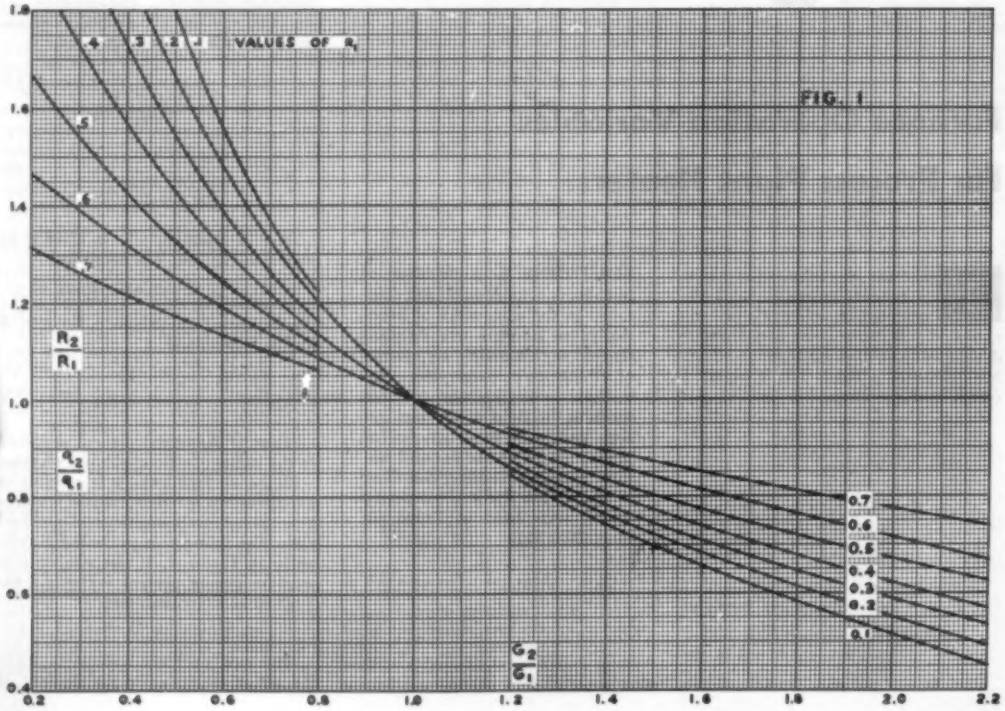
In a given furnace if only operating conditions are changed, A is a constant and,

$$\frac{q_2}{q_1} = \frac{R_2 Q_2}{R_1 Q_1} \qquad (7)$$

In the study of the effect of excess air, G is the variable and Q is constant. It follows then that the variation of q with G is the same as the variation of R with G which was developed in equation (4). Equation (8) gives this relationship and it is also shown graphically on Figure 1.

$$\frac{q_2}{q_1} = \frac{1}{R_1 + (1 - R_1)\frac{G_2}{G_1}} \qquad (8)$$

FIGURE 1



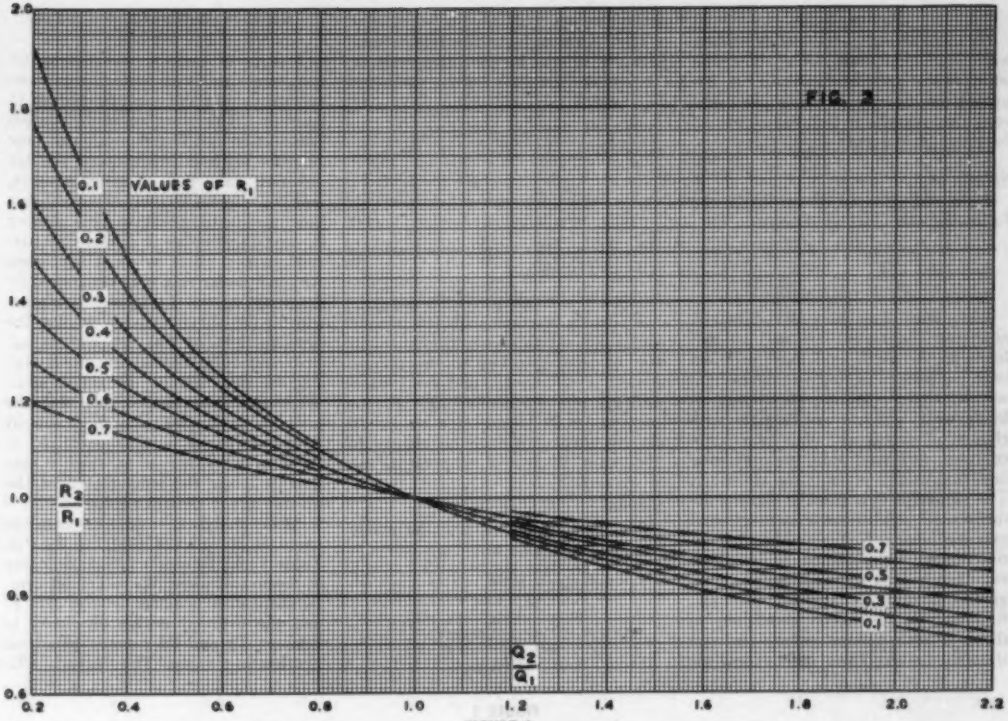


FIGURE 2

The fourth problem is a study of the effect on q of changing the amount of heat liberated in the furnace. In this case both R and Q are variables, and combining equations (5) and (7), the following relationship is obtained.

$$\frac{q_2}{q_1} = \frac{Q_2/Q_1}{R_1 + (1 - R_1)\sqrt{\frac{Q_2}{Q_1}}} \quad (9)$$

Since this is a new form it requires a new set of curves and is shown graphically in Figure 3.

The following example will illustrate the use of equations (8) and (9).

Example 2

A pipestill is used to heat crude oil in a topping plant. Operating conditions are as follows:

Excess air, 50 percent
Percent absorbed in the radiant section, 40 percent
Radiant absorption rate, 9500 Btu. per hour-square foot.

It is proposed to increase the thruput and therefore the duty of the still by 50 percent. At the same time the percent excess air is to be reduced to 30 percent. What new radiant absorption rate is to be expected?

Solution:

In this problem there are two variables, and they must be studied separately. The sequence of operations is optional.

The effect of increasing the duty may be found on Figures 2 and 3. Where Q_2/Q_1 is 1.5, these charts give the following:

From Figure 2, $R_2 = .40 \times .88 = .352$
From Figure 3, $q_2 = 9500 \times 1.32 =$ 12,600 Btu. per hour-square foot.

This is the solution if the excess air is not changed. The next step is to find the effect of reducing the excess air.

$G_2/G_1 = 1.3/1.5 = .867$
From Figure 1, $R_2 = .352 \times 1.095 = .378$
From Figure 1, $q_2 = 12{,}600 \times 1.095 =$ 13,700 Btu. per hour-square foot.

A third variable that must be considered when changes are made in furnace operation is the temperature of the gases leaving the radiant section. This "bridgewall" temperature is important because it affects the operation of the convection section and also must be kept low enough so that it will not cause deterioration of the refractory in that section. The temperature of the flue gases at that point is a direct function of the amount of heat remaining in the gases after radiation has taken place. This heat balance relationship has been developed and plotted on logarithmic coordinates by Nelson.[4] These curves consist of a set of parallel straight lines of heat remaining versus temperature for a series of different percentages of excess air. For any given amount of excess air, an empirical equation may be written as follows:

$$\text{Percent of heat remaining in flue gases} = K(t)^{1.18} \quad (10)$$

The constant K depends upon the type of fuel and the percent excess air.

If a 3 percent allowance is made for radiant section wall losses, the fraction of heat remaining in the flue gas at the bridgewall may be expressed as $(.97 - R)$. Equation (10) may be written relating initial and final conditions to give the following equation where the temperatures are in degrees Fahrenheit.

$$\left(\frac{t_2}{t_1}\right)^{1.18} = \frac{.97 - R_1\left(\frac{R_2}{R_1}\right)}{.97 - R_1} \quad (11)$$

The fifth type of problem then, is that of finding the new bridgewall temperature with any new heat liberation but with the excess air held constant. Equation (5) may be combined with equation (11) but it is easier to handle them separately. A combination of equations (5) and (11) are shown graphically in Figure 4, to relate t and Q.

Example 3

If, in Example 2, the initial bridgewall gas temperature was 1650° F., what new temperature could be expected at that point under the new conditions assuming that the excess air is left at 50 percent?

Solution:

From the data of Example 2, the following constants are known.

$$Q_2/Q_1 = 1.5$$
$$R_1 = .40$$

From Figure 4,

$$t_2 = 1650 \times 1.07 = 1766° \text{ F.}$$

This does not show the effect of changing the excess air and so this leads to the sixth and final problem to be considered in studying the radiant section, that of finding the change in bridgewall gas temperature with change in excess air. This is a more complex derivation than the preceding ones and will be given in the appendix. The subscript *0* is used to signify the theoretical conditions at zero percent excess air—that is if complete combustion could be obtained under these conditions. This makes it necessary to go through two steps in any problem, first convert the initial conditions to those at zero percent excess air, and then to convert from zero excess air to the new conditions.

The following equation relates temperature of gas at the bridgewall to the percent excess air for any condition of t_0 and R_0.

$$\left(\frac{t_2}{t_0}\right)^{1.33} = \left[.97 - \frac{R_0}{1 + (1 - R_0)c_3}\right] \left[\frac{1}{(.97 - R_0)(1 + .808c_3)}\right] \quad (12)$$

Equation (12) is presented graphically in Figure 5.

Example 4

A furnace operates with 100 percent excess air. At this condition the percent of heat absorbed in the radiant section is 40 percent and the bridgewall gas temperature is 1400° F. The burners are to be adjusted to use 30 percent excess air with no change in fuel input. What new temperature can be expected?

Solution:

The first step is to find the conditions at zero excess air.

$$G_0/G_1 = 1.0/2.0 = 0.5$$

From Figure 1, $R_0/R_1 = 1.43$

$$R_0 = .40 \times 1.43 = .572$$

From Figure 5 using R_0 as .572,

$$t_1/t_0 \text{ at 100 percent excess} = .815$$
$$t_0 = 1400/.815 = 1710° \text{ F.}$$

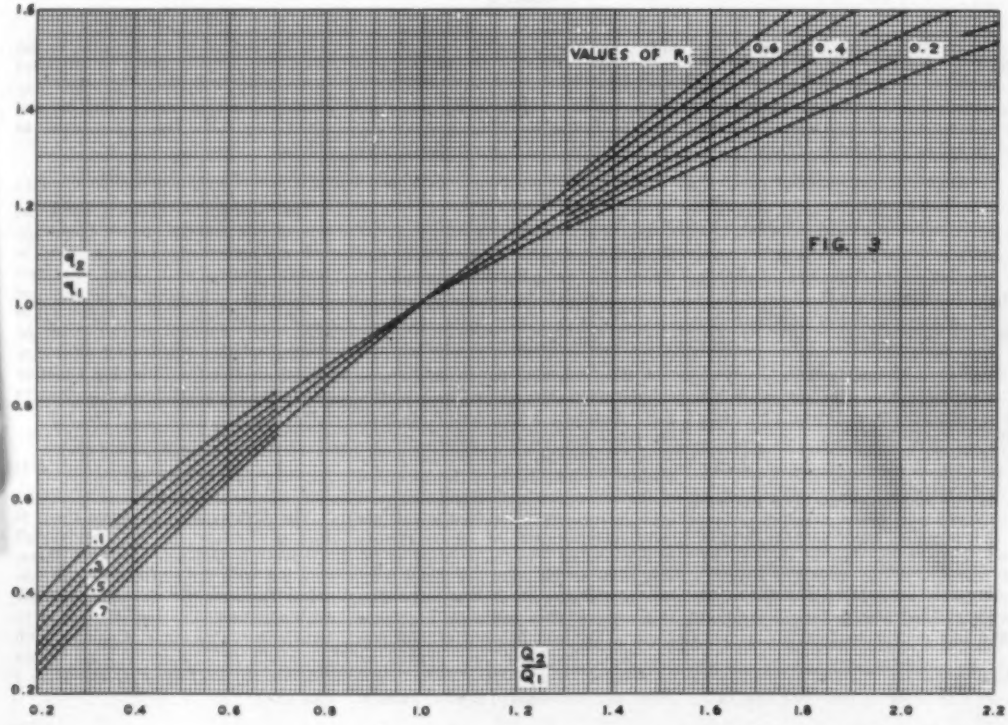
From Figure 5 using R_0 as .572,

$$t_2/t_1 \text{ at 30 percent excess} = .942$$
$$t_2 = 1710 \times .942 = 1620° \text{ F.}$$

A study of furnace operation is not complete without studying how the convection section will react to changes in operation. The operation of the convection section is affected by the oil flow rate, the oil inlet temperature, the flue gas flow rate and inlet temperature, and the film coefficient varies with gas flow rate and temperature. This number of variables makes it difficult to present general rules to cover all cases. Any particular case may be studied by determining the bridgewall temperature by the above methods, finding the new quantity of flue gas and its approximate film coefficient, and knowing the new quantity of oil thruput. With this information and by the methods developed by Buthod[5] the oil temperature rise may be predicted in the convection section, then a heat balance gives the temperature of the oil out of the radiant section.

After studying several example cases, it is believed that the data in Table 1 may be used with a fair degree of accuracy when the oil inlet temperature does not change over 20° F. and the original design efficiency is between 70 and 82 percent based on net heating value. The furnace effi-

FIGURE 3



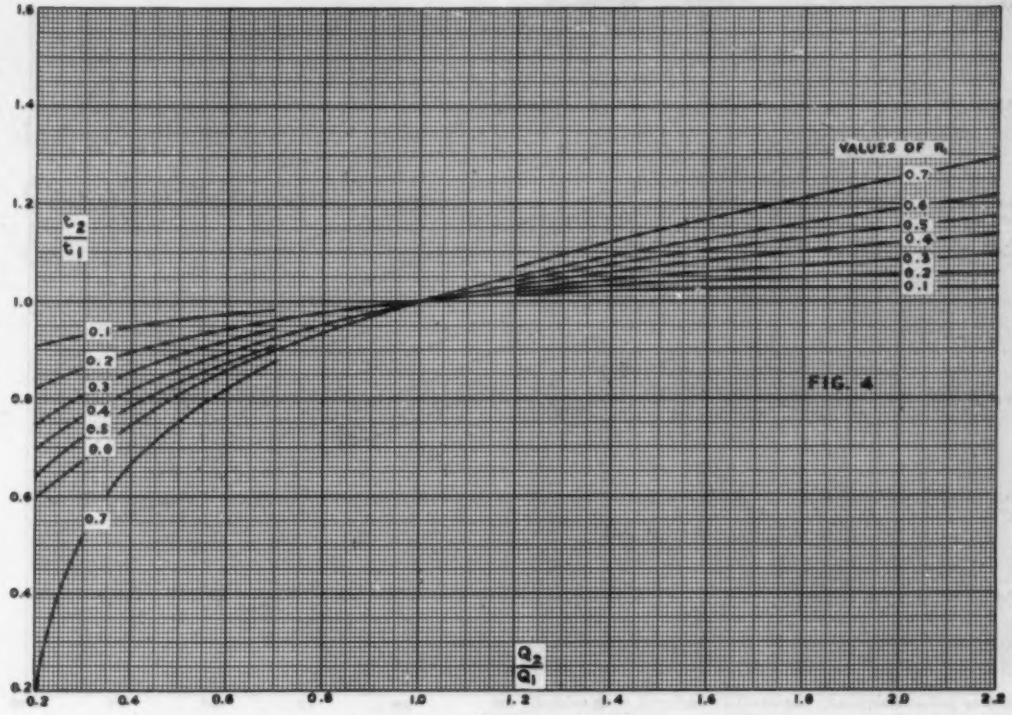


FIGURE 4

ciency ratio is given for a series of excess air values based on the theoretical efficiency at zero percent excess air. The furnace efficiency ratio is also given for a change in heat input based on the efficiency at the original conditions.

TABLE 1

Percent Excess Air	Efficiency Ratio	Q/Q_1	Efficiency Ratio
0	1.00	0.5	1.10
10	.965	0.7	1.06
20	.935	0.9	1.02
30	.915	1.0	1.00
40	.90	1.1	.98
50	.89	1.3	.94
75	.85	1.5	.90
100	.815	....	....
150	.755	....	....

Example 5

A furnace is operating with oil entering the convection at 200° F., entering the radiant section at 325° F., and leaving the radiant section at 500° F. Under these conditions R is .45, excess air is 50 percent and the over-all efficiency is 77 percent. It is proposed to increase the oil rate by 20 percent, increase the fuel oil rate by 30 percent and bring the excess air down to 40 percent. The oil will enter at 200° F. What will be the outlet oil temperature?

NOTATION

A_{rp} — The area of furnace wall that has tubes mounted on it.

a — A factor to convert A_{rp} to effective radiant absorption surface.

e — The percent excess air expressed as a decimal.

G — The number of pounds of air supplied per pound of fuel burned.

Q — The total net heat (above 60° F.) liberated in the flame.

q — The rate of heat absorption. Btu. per hour-square foot of outside tube surface.

R — The fraction of the total heat liberated that is absorbed by the tubes in the radiant section.

t — The temperature of the flue gas as it leaves the radiant section.

SUBSCRIPTS

0 — Denotes conditions when the excess air is zero.

1 — Denotes the initial conditions of operation.

2 — Denotes the final conditions of operation.

Solution:

From Table 1, the efficiency at zero excess air is $.77/.89 = .865$

From Table 1, the efficiency at 40 percent excess air is $.865 \times .90 = .776$

From Table 1, the efficiency at 30 percent increased heat load is

$$.776 \times .94 = .73$$

New over-all oil temperature rise is

$$\frac{(500 - 200) \times 1.3 \times .73 \times 1.0}{1.0 \times .77 \times 1.2} = 308° \text{ F.}$$

Oil Outlet temperature, 508° F.

From Figure 1, $R_1 = 1.04 \times .45 = .468$ due to change in excess air.

From Figure 2, $R_2 = .925 \times .468 = .437$ due to extra heat liberation.

New radiant temperature rise is

$$\frac{(500 - 325) \times 1.3 \times .437 \times 1.0}{1.0 \times .45 \times 1.2} = 180° \text{ F.}$$

Oil temperature out of convection section is $508 - 180 = 328°$ F.

It might appear at first glance that a variation in the fuel oil to process oil ratio would cause a wide variation in furnace efficiency for a given heat input. This, however, is not the case because of the peculiar temperature difference conditions that exist in the convection section. The temperature rise of the oil is so small in comparison with the temperature drop of the gas that the heat removed from the gas is almost independent of the rate of oil rise. The inlet oil temperature has a more pronounced effect.

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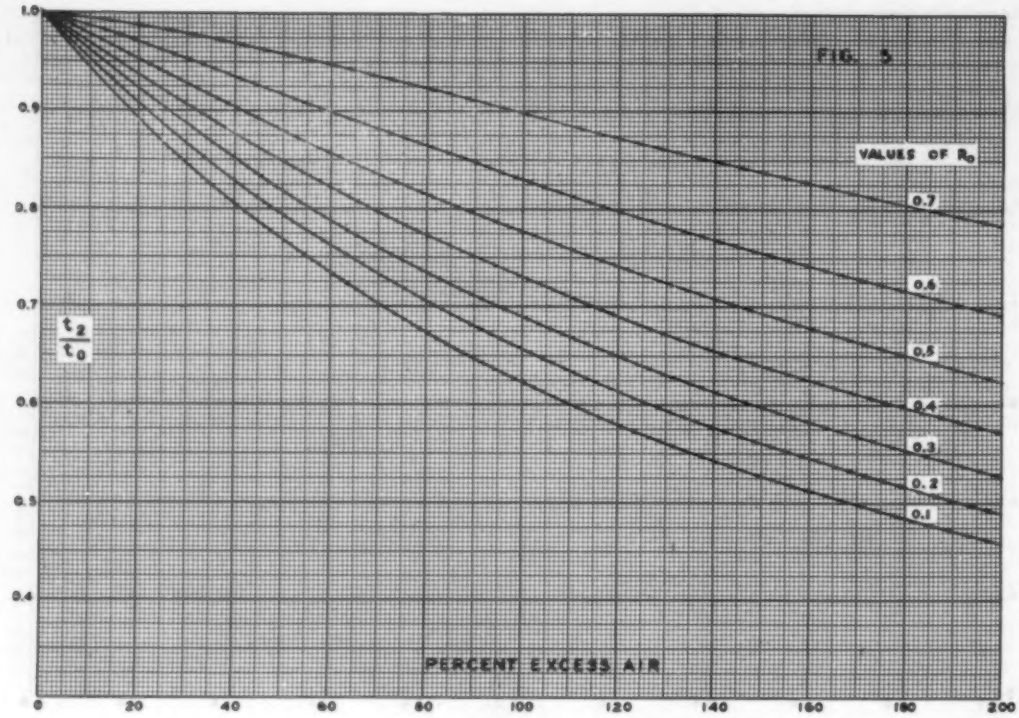

FIGURE 5

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APPENDIX

Derivation of equation relating bridgewall temperature and excess air.

Let Q be the heat liberation in the still under the initial conditions and W be the pounds of fuel used per hour under the same conditions. G_0 represents the pounds of air per pound of fuel at zero excess air.

Pounds of flue gas at zero excess air is $W(G_0 + 1)$.

Heat liberated per pound of flue gas at zero excess air $= Q/W(G_0 + 1)$.

When excess air is added it makes more pounds of flue gas for the same heat developed but since the air added has a different specific heat than the flue gas at zero excess air an equivalent must be devised.

Let e' be the pounds of flue gas having the same heat capacity as e pounds of air. It is necessary to use average specific heats for the two gases, .25 for air and .29 for the flue gas at zero excess air.

$$e' = (.25/.29)e = .862e$$

Heat liberated per pound of flue gas at e'% excess flue gas $=$

$$Q/W(G_0 + 1 + e'G_0)$$

Heat liberated per pound of flue gas at e% excess air $=$

$$Q/W(G_0 + 1 + .862eG_0)$$

Heat content per pound of flue gas at bridgewall with zero excess air

$$\frac{(.97 - R_0)Q}{W(G_0 + 1)} = Kt_2^{1.19}$$

Heat content per pound of flue gas at bridgewall with e% excess air

$$\frac{(.97 - R_2)Q}{W(G_0 + 1 + .862e_2G_0)} = Kt_2^{1.19}$$

* * *

By dividing the two above equations one by the other, the following form results.

$$\left(\frac{t_2}{t_0}\right)^{1.19} = \left(\frac{.97 - R_2}{.97 - R_0}\right)\left(\frac{1}{1 + .862\frac{e_2G_0}{G_0 + 1}}\right)$$

The value of G_0 depends on the type of fuel used and varies between 13 and 17 for common refinery fuels. Using an average value of 15 will result in a maximum error of about 1 percent in the temperature ratio and will be used here. When this substitution is made and the result combined with equation (4), noting that $G_2/G_0 = 1 + e_2$ the following equation, used as equation (12) in the text, is the result.

$$\left(\frac{t_2}{t_0}\right)^{1.19} = \left[.97 - \frac{R_0}{1 + (1 - R_0)e_2}\right]\left[\frac{1}{(.97 - R_0)(1 + .808e_2)}\right] \quad (12)$$

Introduction to Chemical Reaction Calculations

Part I. Introduction

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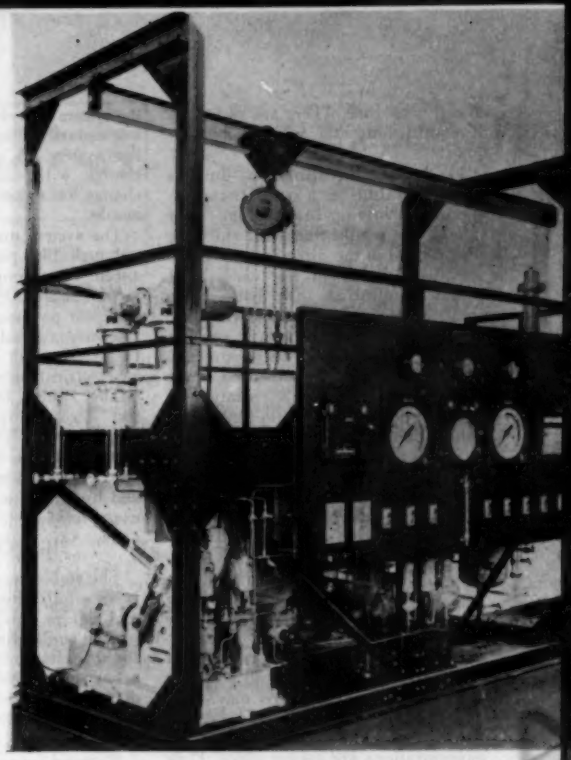


Stainless Steel Autoclave for Continuous Chemical Processing at 4000 psi., 700°F. (Courtesy of Blaw-Knox Construction Company.)

IT is the hope of the authors that this series of articles will clarify the theoretical approach to chemical reaction calculations for process engineers who have not received special training in chemical kinetics and chemical equilibrium. In order to clarify the fundamental laws and derivations used, from an engineering viewpoint, the limitations and assumptions implied but not always concretely stated, will be so stated when possible. In this manner it is hoped that some of the more common pitfalls in the use of these methods may be made evident and thus avoided.

The proper and most economical design of reaction vessels should encompass many widely divergent and interrelated factors. Among these are thruput, yield, operating conditions (temperature, pressure, catalyst, etc.), size of equipment, and corrosion. The question of thruput, of course, is one which can only be determined by an economic study of the plant or installation in question, combined with an investigation of the present and future market value of the product. Possible corrosion difficulties can be evaluated in the light of previous experience, literature data, or laboratory investigations. The remaining factors may be determined by the use of the allied subjects, thermodynamics and chemical kinetics.

The proper use of thermodynamics will enable an engineer to understand some of the important limitations imposed by any chemical reaction. For example, most organic reactions are reversible to some extent. In practical terms, this reversibility means that the theoretical yield of product from the reaction may be only a fraction of that shown by the stoichiometric equation. Thermodynamics will not indicate the length of time needed to reach this equilibrium. In engineering terms, thermodynamics will indicate the maximum yield that can be expected at any given operating temperature or pressure, but will not show the residence time required or the type catalyst that should be employed. On the other hand, chemical kinetics will enable the rate of reaction to be calculated when using different temperatures, pressures, and catalysts, thus determining residence time and the size of the reaction equipment for any specified yield.

AS SPECIFICATIONS for petroleum products become more exacting, the refining industry is utilizing more and more chemical processing steps. Thus the subjects of chemical equilibrium and chemical engineering kinetics, or rate of approach to chemical equilibrium, are of increasing interest to the refiner.

This article is concerned with the definition of equilibrium, some examples of equilibrium, and a brief treatment of chemical equilibrium from the standpoint of chemical engineering thermodynamics. Subsequent articles deal with chemical engineering kinetics.

To develop the subject of chemical reaction calculations in an orderly manner, it is first deemed advisable to present some material on equilibrium, its meaning and its application. Physical equilibrium (no chemical reaction taking place) is first treated, and then material is given on chemical reaction equilibrium. Finally, the rate of chemical reaction (kinetics) and methods for its calculation and correlation are presented.

Equilibrium

Equilibrium is defined as a state of balance between opposing forces or actions. Any system may be said to be in equilibrium when all potentials, or driving forces, acting on it are balanced. In other words, the system undergoes no perceptible, progressive

change with time. There are two types of equilibrium that will be encountered:

1) **Actual Equilibrium**—In this type of equilibrium a small change in one of the driving forces from either side of the equilibrium will shift the equilibrium in the direction of the potential. Included in the concept of actual equilibrium are both batch equilibrium and flow equilibrium. Batch equilibrium is the type encountered in a closed or batch process. When this condition is reached, there is no net change in concentration of any part of the system with time. Flow equilibrium may be reached in a flow or continuous process. This condition is encountered when the concentration at any point in the system remains constant as time is varying. However, the concentration changes uniformly and consistently at a progressive succession of points throughout the system. Batch equilibrium is exemplified by a container of nitrogen gas. The system is homogeneous, and no differences in concentration exist. However in a polyphase system, or in a system containing a solid, there may exist concentration differences in the system, but no net changes in any of the concentrations are taking place. Flow equilibrium may be exemplified by a gas phase reactor. The feed gas contains little or none of the desired component. The effluent gas contains an appreciable amount of this component, and there is a constant increase in concentration as a given amount of gas passes through the reactor.

2) **Pseudo Equilibrium** — True equilibrium is not attained in this type of so-called "equilibrium," because there is an unbalanced driving force and a tendency for change. However, due to a high resistance, the change occurs very slowly and may for all practical purposes be considered zero. Consequently this condition is treated as though equilibrium existed. One example of pseudo equilibrium is a mixture of hydrogen and oxygen gases at a temperature of 25° C. The chemical driving force for reaction of these gases to form water is very high; yet the rate of reaction is very low and no change in concentrations may be detected over long periods of time. Another example is found in the tendency of activated alumina of a certain crystal structure to revert to inert alumina of quite different crystal structure. However, many years would be required for appreciable change to be effected at 25° C.

The concept of equilibrium is an elusive one, and the following factors are helpful in clarifying it:

Small instantaneous changes may occur at random. The composition of the system at a given point may change momentarily, due to transient effects in the system. A small temperature change will cause a small volume change in a gaseous system, for example.

The system may be in equilibrium, although like potentials are not balanced. For example when a zinc plate is placed in sulfuric acid solution, a chemical potential results. This potential may be balanced by pressuring the system with hydrogen gas, or by an electrical potential.

The system is rarely at complete rest. Two reverse chemical reactions may be proceeding at equal rates, such that there is no net change in the system. The reaction of carbon monoxide and hydrogen to yield methanol is an example of such reaction:

$$2H_2 + CO \rightleftharpoons CH_3OH$$

The stable condition for any system is an equilibrium state, and any system not in equilibrium tends to approach equilibrium. The time required for this attainment may be as little as a few seconds (a chemical reaction of explosive violence) or it may be as much as many years, as indicated above.

Rate of approach to equilibrium may be very slow. For this reason it is desirable (where possible) to approach a point of equilibrium from both sides to determine its exact location. In the case of a chemical reaction, this would mean starting with pure reactants and maintaining reaction conditions until an equilibrium point had apparently been reached. Then the procedure would be repeated with pure products. The equilibrium point is then defined as that point where the percent compositions of the two systems are the same. No further change can then be evidenced in either system.

Nomenclature

(Units may change; thus they are indicated at the point of use)

- p or π = total pressure
- V = volume
- T = temperature
- N = lb mols
- P = vapor pressure
- x = mol fraction of a component in the liquid
- y = mol fraction of a component in the vapor
- q = heat transferred to system
- H = enthalpy
- p_L = partial pressure in liquid
- p_V = partial pressure in vapor
- K = phase or chemical equilibrium constant
- S = entropy
- E = internal energy
- w = gas expansion work
- w' = shaft work
- F = free energy
- f = fugacity
- ϕ = fugacity/pressure
- f'' = fugacity pure liquid
- f' = fugacity pure vapor
- f = fugacity in solution
- f^o = standard state fugacity
- F^o = standard state free energy
- a = activity

Pressure Equilibrium

Pressure equilibrium is usually quite readily attained. Consider two containers containing gases at different volumes and pressures (Figure 1). The temperature is held constant at the same value in both containers. The gases are considered ideal; i.e., they follow the perfect gas law. The equilibrium pressure after opening the connecting valve is reached rapidly and may be easily calculated, as shown in Example 1.

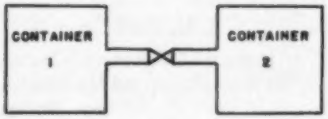


Figure 1

Subscripts 1, 2, refer to containers 1 and 2, respectively.

- π — pressure, psia.
- V — volume, cu. ft.
- N — lb. mols of gas (wt/MW)
- T — temperature, °Rankine
- R — gas constant, (10.73 for these units)
- π_f — equilibrium pressure, psia.

It follows from the perfect gas law,

$$\pi V = NRT$$

that $$\pi_f = \frac{(N_1 + N_2)RT}{(V_1 + V_2)}$$

Example 1:

For these initial values,

$T = 40°$ F. (500 °R.)
$\pi_1 = 15$ psia.
$V_1 = 15$ cubic feet
$N_1 = 0.0419$
$\pi_2 = 20$ psia.
$V_2 = 25$ cubic feet
$N_2 = 0.0930$

$$\pi_f = \frac{(0.0419 + 0.0930) \times 10.73 \times 500}{(15 + 25)} = 18.1 \text{ psia.}$$

Thermal Equilibrium

If bodies at different temperatures are brought in contact, heat transfer will take place until the driving force (temperature difference) is zero. If steam, ice, and liquid water are brought into contact, the heat content of the system per unit mass is higher than that of the ice alone and lower than the steam alone. The exact condition of the system must be determined by calculation:

10LB.	20LB.	30LB.
STEAM, 212°F	ICE, 32°F	WATER, 60°F
14.7 PSIA	14.7 PSIA	14.7 PSIA

Figure 2

Example 2:

If the quantities of ice, steam, and water shown in Figure 2 are brought into contact at constant pressure, calculate the resulting temperature of the mixture and define its state.

Basis: Liquid Water at 32° F. (Enthalpy is zero, as defined by standard steam tables.)

Enthalpies may be used, since $q = \Delta H$ at constant pressure.

COMPONENT	#	ΔH/#	ΔH
Steam	10	1150	11,500
Water	50	28.0	1,400
Ice	20	−144	−2,880
Total	80	.....	10,020

$$\Delta H = \frac{10{,}020}{80} = 128 \text{ Btu/lb. for the final mixture.}$$

From the steam tables, it is seen that the mixture is all liquid at 160 °F.

Phase Equilibrium

The concept of phase equilibrium is somewhat more complicated than that of pressure or thermal equilibrium. When two or more components are mixed under conditions such that two or more phases are present, equilibrium concentrations are reached in each phase. Equilibrium under these circumstances is defined as the point where the "effective pressure" of a given component in one phase is equal to the "effective pressure" of that component in all the other existing phases. This effective pressure is defined as partial pressure, and at equilibrium the partial pressure exerted by a compound must be the same for each phase in which the component exists. Ordinarily the actual value of partial pressure is of no consequence, but it is extremely important to remember that partial pressure is the driving force. This fact makes it possible to calculate the temperature, pressure, an concentrations in the liquid and gaseous phases. These are all items of practical importance in any process design or performance calculations involving phase equilibria.

The bases for liquid-gas phase equilibrium calculations are found in Raoult's and Dalton's laws. Raoult's law states that the partial pressure of a given component in the liquid phase is the product of its vapor pressure (as a pure liquid at the given temperature) and its mol fraction in the liquid.

$$\text{Or, } p_L = Px$$

where p_L is partial pressure in the liquid

P is the vapor pressure of the pure component

x is the mol fraction of the component in the liquid.

Dalton's Law states that the partial pressure of a given component in the vapor phase is the product of the total pressure on the system and its mol fraction in the vapor.

$$\text{Or, } p_V = \pi y$$

p_V — partial pressure in the vapor

π — total pressure on the system

y — mol fraction of the component in the vapor

At equilibrium, the partial pressure of the component in the liquid phase must be equal to the partial pressure of the component in the vapor phase.

$$\text{Or, } Px = p_L = p_V = \pi y \qquad (1)$$
$$Px = \pi y$$
$$y/x = P/\pi = K$$

The last relationship $(y/x = K)$ is apparently a function only of the total pressure and temperature of the system. If the compounds in the mixture vary widely in type, K should also be a function of the composition. However, this case occurs only rarely, and where the compounds in the mixture are of the same general type, K is independent of composition. In general, for hydrocarbons $K = P/\pi$, when

P_r is less than 0.10

T_r is greater than 0.80

π is less than 65 psia.

P_r and T_r are reduced pressure and temperature, respectively. These terms are defined as the actual values divided by the critical values. Absolute values of pressure and temperature must be used in all cases, although the actual scale makes no difference. For conditions falling outside the limits imposed by the above restrictions, K charts for hydrocarbons have been calculated and/or observed experimentally.

No examples of phase equilibrium calculations will be given, since it is felt that the great majority of the readers are familiar with these calculations.

Chemical Equilibrium

The driving forces for chemical equilibrium are not such tangible or measurable items as temperature or gauge pressure. If a system is being investigated for a possible chemical equilibrium condition, the exact approach would be to calculate the change in entropy of the system as the composition of a mixture of reactants and products is changed slightly. For a true equilibrium, every possible infinitesimal change is reversible and the entropy of the system remains constant. This type calculation is very difficult or impossible to make, and for these reasons, various other thermodynamics functions have been investigated as criterion for equilibrium. One of the most important of these functions is a quantity called free energy, F. Free energy is equal to the shaft work obtainable for useful purposes from an isothermal process, assuming all work is either expansion or compression work:

$$dF = Vdp \qquad (2)$$

The term, Vdp, will be recognized as the differential form of shaft work. If the system is at equilibruim, all driving forces have been reduced to zero, and the system is not capable of performing any useful work. This fact in turn indicates that the free energy of the system is a measure of the driving forces existing and must be at a minimum when chemical equilibrium is reached. This behavior is shown in Figure 3, where the total free energy of the system is shown versus the amount of one of the reaction compounds (A) present. It will be noted that merely stating $\Delta F = O$ is not an indication of equilibrium. It is possible that such calculations could be made between points 1 and 2, indicating an equilibrium condition that did not exist. A preferred method of signifying equilibrium is to state that either $dF = O$ or $dF/dN = O$.

Free energy, a thermodynamic point function, because it is defined in terms of both enthalpy and entropy, is rarely ever calculated with respect to an absolute zero level. Rather, like enthalpy and entropy, it is evaluated for a change in conditions or with respect to some datum plane. The calculation of the necessary values of free energy changes are usually made through the media of a tool called fugacity. Consequently, it will be necessary to digress somewhat to investigate the subject of fugacity.

Unfortunately, fugacity has been delegated in the minds of many students and engineers to a position of mystery and placed on the shelf. Like the quantities, enthalpy, phase equilibrium constants, etc., fugacity is an engineering tool the usefulness of which will continue to grow as more and more data are collected and published in appropriate form. For these

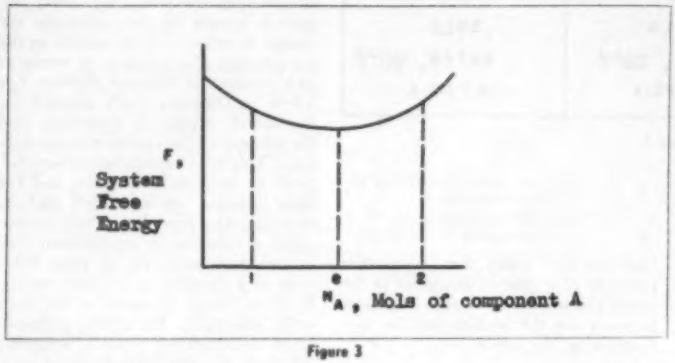


Figure 3

reasons, a detailed description of fugacity is in order.

Fugacity was originally conceived by Lewis[1] in 1901. The need for a concept of this type may be seen by a comparison of the calculation of the free energies of an ideal and real gas. From a previous equation

$$dF = Vdp \qquad (2)$$

Integration of this equation for an ideal gas obeying the relationship, $PV = RT$, yields:

$$\int dF = \int Vdp = \int \frac{RT}{p}\, dp$$

$$F = RT \ln p + C$$

$$\text{or } \Delta F = F_2 - F_1 = RT \ln p_2/p_1$$

This development discloses that the free energy of an ideal gas may be calculated easily. For a real gas the integration becomes much more difficult and led Lewis to propose the quantity, fugacity, to be defined as

$$F = RT \ln f + B \qquad (3)$$

B is an integration constant which is a function of temperature only. This equation implies that the free energy of compound in any physical state may be calculated by the substitution of the appropriate fugacity and integration constant. It also indicates that fugacity is expressed in units of pressure, and that the fugacity and pressure of an ideal gas are identical

A means of calculating fugacities may be seen by using Equation 2 and by differentiating Equation 3.

$$RT d\ln f = Vdp$$

$$\text{or } \ln f = \int Vdp/RT \qquad (4)$$

The integration indicated may be performed by expressing V as a function of p. For any gas, the appropriate relationship may be found in any equation of state. The method of integration is illustrated below for the ideal compressibility, and van der Waals' equations of state. In addition, the integrated forms of some of the more common equations are shown.

For an ideal gas

$$\int_e^f d\ln f = \int_e^p \frac{V}{RT}\, dp$$

$$\frac{1}{p} = \frac{V}{RT}$$

$$\int_e^f d\ln f = \int_e^p \frac{dp}{p}$$

$$\ln f = \ln p$$

$$f = p$$

For gas obeying the compressibility equation

$$\int_e^f d\ln f = \int_e^p \frac{V}{RT}\, dp$$

$$\frac{Z}{p} = \frac{V}{RT}$$

$$\int_e^f d\ln f = \int_e^p Z\, \frac{dp}{p} =$$

$$\int_e^p \left[\frac{(Z-1)+1}{p}\right] dp$$

$$\int_1^{f/p} d\ln \frac{f}{p} = \int_e^p \frac{Z-1}{p}\, dp$$

$$\ln \frac{f}{p} = \int_e^p \frac{Z-1}{p}\, dp \qquad (5)$$

The compressibility factor, Z, is a function of the system pressure and thus the expression $\int \frac{Z-1}{d}\, dp$ is most easily integrated graphically. Three steps in this derivation which may not be quite clear are: 1) the substitution of $d\ln p$ for dp/p, 2) the addition of $d\ln f - d\ln p$ to equal $d\ln f/p$, and 3) the use of the fact $\lim_{p \to o} \frac{f}{p} = 1$ as an integration limit.

For gas obeying van der Waals equation

$$\left(p + \frac{a}{V^2}\right)(V - b) = RT,$$

the resulting expression is

$$\ln f = \frac{b}{V-b} + \ln\left(\frac{RT}{V-b}\right) - \frac{2a}{RTV} \qquad (6)$$

In addition to the equations derived above, there is available a quicker and more convenient method of calculating the fugacity of most compounds. This is by means of the term, f/p, called the fugacity coefficient and usually abbreviated by the symbol, δ. Values of this coefficient have been calculated for various compounds and have been found to correlate on a reduced temperature and pressure basis. A plot of this type may be found in any standard work on chemical engineering thermodynamics.

Example 3: Calculate the fugacity of normal butane at 1044 psia. and 306 F.

$$Pr = \frac{p}{p_c} = \frac{1044 + 14.7}{36.0 \times 14.7} = 2.00$$

$$Tr = \frac{T}{T_c} = \frac{306 + 460}{766} = 1.00$$

$$\delta = 0.38$$

$$f = \delta p = 0.38 \times 1058.7 = 402.8 \text{ psia.}$$

This example emphasizes a fact previously noted, i.e., the units of measurement of fugacity and pressure are identical. This fact has led to the general concept of fugacity being a corrected pressure. This concept is correct but may lead to certain erroneous conclusions as to the usefulness of fugacity. For instance, it is incorrect to use fugacity in the perfect gas law as a corrected pressure and expect to get a correct correlation between volume and temperature.

Example 4: Calculate the volume occupied by one pound mol of normal butane at 1044 psia. and 306 F.

From the compressibility equation of state

$$pV = ZRT$$

$$V = ZRT/p$$

From Example 3

$$Tr = 1.00;\ Pr = 2.00;\ Z = 0.305$$

$$V = \frac{0.305 \times 10.735 \times 766}{1060}$$

$$= 2.37 \text{ cubic feet}$$

From the erroneous equation

$$fV = RT$$

$$V = RT/f$$

From Example 3, $f = 402.8$

$$V = \frac{10.735 \times 766}{402.8} = 20.4 \text{ cubic feet}$$

With the particular conditions and compound chosen the resultant error was 1000 percent. For this reason, it is perhaps best to view fugacity as a measure of the escaping tendency of a compound. This definition connotes that in a multiphase-multicomponent equilibrium mixture, the escaping tendency or fugacity of each component is identical in all phases. If this

were not true, and the escaping tendency of the component would be greater in one phase and material would transfer between phases until the escaping tendencies were equal.

This equality of fugacities is used in the calculation of the fugacity of a liquid or a solid. But as will be shown, such calculations always involve a knowledge of the fugacity of the gaseous phase. Figure 4 shows the general shape of a phase diagram for a single component. It is desired to calculate the fugacity of a liquid whose phase condition is given by the coordinates, P_2 and T_1. To make this calculation, it will be necessary to first calculate the fugacity of the vapor at point p_1 and T_1. At this point the liquid and vapor phases are in equilibrium and the fugacities of the two phases are equal.

Let $f_1 = f(\text{vapor}) = f(\text{liquid})$ at T_1, p_1

These data can be calculated by any of the methods previously presented.

$$\text{Then } \int_{f_1}^{f_2} d\ln f = \int_{p_1}^{p_2} V\,dp$$

$$\ln f_2 = \ln f_1 + V(p_2 - p_1) \qquad (7)$$

Note: V for a solid or liquid is relatively independent of pressure and therefore may be integrated as a constant in most cases. If extremely high pressure changes are involved, graphical integration may be employed.

If the system under consideration is composed of a mixture of components rather than one pure component, the calculation of the fugacity of any component in the liquid phase may be calculated by starting with the relationship

$$\bar{f}(\text{vapor}) = \bar{f}(\text{liquid}) \qquad (8)$$

and employing Lewis' fugacity rule, which states that the fugacity of a compound in solution is equal to the product of the fugacity of the pure compound at the temperature and pressure of the solution multiplied by the mol fraction of the compound in the solution, we get

$$\bar{f}(\text{vapor}) = f'y$$

$$\bar{f}(\text{liquid}) = f''x$$

$$f'y = f''x$$

$$f'' = f'\frac{y}{x}$$

$$\text{but } y/x = K$$

$$f'' = f'K \qquad (9)$$

The relationship shown in Equation 9 is between the fugacities of the pure compound in the vapor (f') and liquid (f'') states, and as such is valid in any region for which phase equilibrium data are available.

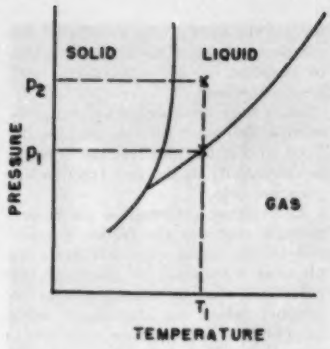


Figure 4

Calculation of the fugacities of solids is done by a method similiar to the vapor pressure calculation just described. The fugacity of the liquid is calculated at the freezing point, and then Equation 7 is used with the proper substitutions of pressure and volume to obtain the desired fugacity.

It should be pointed out here that fugacity is of value for calculation of quantities other than free energy. It may be used to calculate phase equilibrium constants and activities.

With the necessary background material on fugacity now in mind, it becomes possible to set up the required equations for the determination of chemical equilibrium. For the general case, let us consider the reaction

$$aA + bB \rightleftharpoons rR + sS \qquad (10)$$

The total free energy of such a mixture of compounds is a function of the amounts of each component present, the pressure on the system and the temperature of the system. It may be shown that

$$-\Delta F^\circ = RT \ln K_a \qquad (11)$$

$$\text{where } \frac{a_R^r a_S^s}{a_A^a a_B^b} = K_a \qquad (12)$$

The usefulness of this equation may be expanded by developing several relationships between activity, a, and other variables which may be more easily measured.

$a = \frac{\bar{f}}{f^\circ}$, by definition of activity.

f° = fugacity of compound under standard state conditions.

The fugacity in solution, $\bar{f}$, may be evaluated by employing Lewis' fugacity rule, which states that $\bar{f}$ is equal to the fugacity of the pure compound times its mol fraction in solution:

$$\bar{f} = f'x$$

$$a = \frac{f'x}{f^\circ}$$

Since $f' = \delta\pi$, from definition of δ,

$$a = \frac{\delta\pi x}{f^\circ}$$

$$\text{But } x = \frac{\text{mols of component}}{\text{total mols present}} = \frac{n}{N_T}, \text{ so}$$

$$a = \frac{\delta\pi n}{f^\circ N_T}$$

Too, $n = cV_T$, where c is the concentration per unit volume, and V_T is total volume,

$$\text{and thus, } a = \frac{\delta\pi C V_T}{f^\circ N_T}$$

Using the same definition for K, i.e. that K of any quantity,

$$K\,a = \frac{a_R^r a_S^s}{a_A^a a_B^b},$$

these equalities for K_a are derived,

$$K_a = \frac{\bar{K_f}}{K_f^\circ} = \frac{K_f' K_\delta}{K_f^\circ} = \frac{K\delta K_\delta(\pi)^{\Delta n}}{K_f^\circ} \qquad (13)$$

$$= \frac{K\delta K_a}{K_f^\circ}\left(\frac{\pi}{N_T}\right)^{\Delta M}$$

$$= \frac{K\delta K_c}{K_f^\circ}\left(\frac{\pi V_T}{N_T}\right)^{\Delta n}$$

$$\text{where } \Delta n = r + s - a - b. \qquad (14)$$

Before these equations can be put to practical use, it is necessary to determine the variation of K_a or ΔF° with temperature and pressure.

It can also be shown that

$$\Delta H^\circ = \Delta H_o + \Delta\alpha T + \Delta\beta\frac{T^2}{2} + \frac{\Delta\delta T^3}{3} \qquad (15)$$

$$\frac{\Delta F^\circ}{T} = \frac{\Delta H_o}{T} - \Delta\alpha \ln T - \frac{\Delta\beta T^2}{2} - \frac{\Delta\delta T^3}{6} + I \qquad (16)$$

In actual practice, use of this equation is contingent on the calculation of the two intergration constants ΔH_o and I. However, since only two constants are involved, any two independent sets of data will be needed. These data may take the form of:

1) a heat of reaction at standard state pressure (ΔH°) plus an analysis of an equilibrium mixture
2) ΔH° plus a value of ΔF°
3) two values of ΔF° at different temperatures
4) two equilibrium analyses at different temperatures.

Variations in pressure will not affect either ΔF°, or K_a. This independence is occasioned because ΔF°, is measured at an arbitrarily selected pressure, rather than the actual reaction pressure. The proof that K_a and ΔF° are independent of reaction pressure does not imply that equilibrium yield are also independent of pressure. By using K_a as an indication of the yields expected it can be seen from the equation

$$K_a = \frac{N_R^r N_S^s}{N_A^a N_B^b} = \frac{K_a K_f^\circ}{K\delta}\left(\frac{N_T}{\pi}\right)^{\Delta n} \qquad (17)$$

that even if $\Delta n = 0$, changes in pressure which decrease K_δ will increase product yields. Alternately if K_δ is relatively independent of pressure, the yield of product will decrease with in-

creasing pressure for reactions for which $\Delta n > 0$ and increase when $\Delta n < 0$.

Heterogeneous Reactions

The previous equations, because of the inclusion of the gas law in their derivations are only applicable to homogeneous gas systems. Occasionally the system encountered will have two or more separate and distinct phases, involving a combination of gas, liquid, or solid phases. Equilibrium in this type system is still indicated at $dF = 0$. Therefore, the equation,

$$K_a = \frac{a_N^{\nu} a_S^{\sigma}}{a_A^{\alpha} b_B^{\beta}},$$

is valid, and complete calculations depend only on the determination of the activities of each component.

The activity of any gas may be calculated as previously shown:

$$a = \frac{f}{f^0} = \frac{\delta \pi x}{f^0}$$

The activity of a pure liquid or solid is usually arbitrarily designated as unity under a specified pressure. This activity will remain constant at unity until high pressures are reached.

The activity of liquids or solids present in solution may be calculated by judicious selection of the arbitrary standard state at which the activity of the compound is unity.

a) If the standard state is defined as the pure substance under the pressure of the system, the activity of the component is equal to the mol fraction in an ideal solution, but varies with system pressure.

b) If the component is only slightly soluble the standard state may be defined so that the mol fraction is equal to the activity as the mol fraction approaches zero.

For further information on heterogeneous reactions the reader is referred to the more complete texts on physical chemistry and chemical calculations. The important point to remember when calculating or using heterogeneous equilibrium constants is that all standard states must be clearly specified in order to avoid extreme errors in equilibrium predictions.

It might be advantageous at this point to review and coordinate the concepts of activity and fugacity for both homogeneous and heterogeneous systems. Activity, $a, = f/f^0$.

Standard States

Gaseous

a) $f^0 = 1.0$

b) $f^0 = f$ of pure compound at temperature and pressure of the system

Liquids and Solids

a) Pure substance under system pressure

b) Volatile, above 1 atmosphere—pure substance under its vapor pressure

c) Non Volatile—Pure compound at 1 atmosphere

Solutions

a) Pure component under pressure of 1 atmosphere, vapor pressure or system pressure

b) Slightly soluble materials — mol fraction, $x, = a$, as x approaches 0.

It is realized that the equations derived on the preceding pages do not indicate their extreme usefulness. In order to clarify any questionable points several practical examples covering the application of these equations follow.

The relationships between the K's, ΔF^0, and the equation relating change in ΔF^0 with temperature are shown in Example 5.

Example 5: At 4000° K and 1958.7 mm pressure, water is 3.29 percent dissociated. Calculate I for the reaction,

$$2H_2 + O_2 \rightleftarrows 2H_2O,$$

given that ΔH^0 at 60° F. and 1 atmosphere for this reaction is —103,800 Btu/lb mol of water formed.

Molal Heat Capacities

C_pH_2: $6.88 + 0.018 \times 10^{-3}T + 0.029 \times 10^{-6}T^2$

C_pO_2: $6.13 + 0.83 \times 10^{-3}T - 0.084 \times 10^{-6}T^2$

C_pH_2O: $6.89 + 1.825 \times 10^{-3}T - 0.106 \times 10^{-6}T^2$

Solution:

For equation as written:

	$\Delta\alpha$	$\Delta\beta$	$\Delta\delta$
Products:	+13.78	+2.65	−0.212
Reactants:	−19.89	−0.87	+0.026
	−6.11	+2.78	−0.186

$$\Delta H^0 = \int_{\circ}^{T} (-6.11 + 2.78 \times 10^{-3}T - 1.86 \times 10^{-7}T^2)dT$$

$$\Delta H^0 = -6.11\,T + 1.39 \times 10^{-3}T^2 - 0.62 \times 10^{-7}T^3 + \Delta H_\circ \text{ at } 60^\circ \text{ F, or } 520^\circ \text{ R,}$$

$$-207{,}600 = -6.11 \times 520 + 1.39 \times 10^{-3} \times 270{,}400 - 0.62 \times 10^{-7} \times 1.406 \times 10^{8} + \Delta H_\circ$$

$$\Delta H_\circ = -207{,}600 + 3{,}180 - 370 + 9$$

$$\Delta H_\circ = -204{,}781 \text{ BTU/\# mol} = -113{,}800 \text{ cal/gm mol}$$

$$\frac{\Delta F^0}{T} = 6.11 \ln T - 1.39 \times 10^{-3}T + 0.31 \times 10^{-7}T^2 - \frac{113{,}800}{T} + I$$

$$\frac{\Delta F^0}{T} = -R \ln K_a$$

$$2H_2 + O_2 \rightleftarrows 2H_2O$$

N: 0.0329 0.0165 0.9671

$$N = 0.0329 + 0.0165 + 0.9671 = 1.0165$$

$$\Delta n = 2 - 3 = -1$$

Continuously rotating autoclave for moderate pressures, provided with steam heat. (Courtesy of Blaw-Knox Construction Company.)

$$K_a = \frac{K\delta \; K_\pi \left(\frac{\pi}{N_T}\right)^{\Delta n}}{K_f^{\Delta n}}$$

$$K_a = \frac{(0.9671)^2}{(0.0329)^3\,(0.0165)} = 5.24 \times 10^4$$

$$T = 4000 \times 1.8 = 7200^\circ \text{ R}$$

$$\pi = 1958.7/760 = 2.58 \text{ atmos}$$

COMPD	T_c, °R	T_r	p_c, atm	p_r	δ
H_2O	1165	6.18	218	0.0118	1
H_2*	59.7	106.2	12.8	0.124	1
O_2	278	25.9	49.7	0.0519	1

* $T_r = \frac{T}{T_c + (8 \times 1.8)}$ $p_r = \frac{p}{p_c + 8}$ for H_2

$$K\delta = 1$$

$$K_a = \frac{1 \times 5.24 \times 10^4 \times \left(\frac{2.58^{-1}}{1.0165}\right)}{1} = 2.06 \times 10^4$$

$$-R \ln K_a = 6.11 \ln T - 1.39 \times 10^{-3} T + 0.31 \times 10^{-6} T^2 - \frac{113{,}800}{T} + I \text{ at } 4000^\circ \text{ K.}$$

$$-1.987 \times 9.93 = 6.11 \times 8.30 - 5.56 + 0.50 - 29.45 + I$$

$$I = 29.45 + 5.56 - 19.70 - 0.50 - 50.70$$

$$I = -35.89$$

The evaluation of the constants in the equation relating change in ΔF° to change in temperature is shown in example, using experimental data and standard values from the literature.

Example 6: **One mol each of hydrogen, nitrogen, and ammonia are charged to a vessel and brought to a temperature of 1200° K. and a pressure of 1000 mm. At that point concentrations are measured, and it is found that 40 percent of the ammonia charged has dissociated.**

For the reaction,

$$1/2\ N_2 + 3/2\ H_2 \rightarrow NH_3,$$

ΔH° at 300° K = —17,000 cal per gm mol NH_3 formed

Calculate I for this reaction and set up an equation for ΔF° in terms of temperature.

Molal Heat Capacities

$$C_pN_2: 6.30 + 0.505 \times 10^{-3} T - 0.036 \times 10^{-6} T^2$$

$$C_pH_2: 6.88 + 0.018 \times 10^{-3} T + 0.029 \times 10^{-6} T^2$$

$$C_pNH_3: 8.90 + 0.860 \times 10^{-3} T - 0.720 \times 10^{-6} T^2$$

Solution:

$$K_a = \frac{K\delta \; K_\pi \left(\frac{\pi}{N}\right)^{\Delta n}}{K_{f_a}}$$

At high temperatures and low pressures, $K\delta = 1$, for all practical purposes.

For $3/2\ H_2 + 1/2\ N_2 \rightarrow NH_3$, $\Delta n = 1 - 2 = -1$

N: 1.6 1.2 0.6, at equilibrium

$$N = 1.6 + 1.2 + 0.6 = 3.4$$

Reaction vessels for production of GR5 type synthetic rubber. (Courtesy of Blaw-Knox Construction Company.)

$$K_a = 1 \times \frac{0.6}{(1.2)^{1/2}\,(1.6)^{3/2}} \left(\frac{3.4}{1000/760}\right)$$

$$K_a = 0.70$$

$$\frac{\Delta F^\circ}{T} = -R \ln K_a = -1.987 \ln 0.70$$

$$\frac{\Delta F^\circ}{T} = (1.987)\,(0.357) = 0.709$$

For equation as written:

	$\Delta\alpha$	$\Delta\beta$	$\Delta\delta$
Products:	+ 8.90	+0.860	—0.720
Reactants:	— 3.15	—0.252	+0.018
	—10.32	—0.027	—0.044
	— 4.57	+0.581	—0.766

$$\Delta H^\circ = -4.57\ T + 0.290 \times 10^{-3} T^2 - 0.249 \times 10^{-6} T^3 + \Delta H_o \text{ at } 300^\circ \text{ K.}$$

$$\Delta H_o = -17{,}000 \text{ cal/gm mol}$$

$$\Delta H_o = -17{,}000 + 1370 - 26 + 7$$

$$\Delta H_o = -15{,}650 \text{ cal/gm mol at } 1200^\circ \text{ K.}$$

$$\frac{\Delta F^\circ}{T} = 0.709 = 4.57 \ln 1200 - 0.290 \times 10^{-3}(1200) + 0.125 \times 10^{-6} T^2 (1200^2) - \frac{15{,}650}{1200} + I$$

$$I = 0.709 - 32.40 + 0.35 - 0.18 + 13.03$$

$$I = -18.49$$

$$\frac{\Delta F^\circ}{T} = 4.57 \ln T - 0.290 \times 10^{-3} T + 0.125 \times 10^{-6} T^2 - \frac{15650}{T} - 18.49$$

To show the effect of an excess of reactant above the stoichiometrical quantities, consider Example 7.

* * *

Example 7: **The plant is producing methanol under the following conditions using 100 percent excess hydrogen. Calculate the percent once-through conversion of CO to methanol.**

$$\pi = 204 \text{ atmospheres}$$

$$T = 1176^\circ \text{ R}$$

$$K_a = 1.355 \times 10^{-4}$$

$$K\delta = 0.502$$

$$K_p = 2.7 \times 10^{-4} \text{ (at 204 atmos)}$$

$$CO + 2H_2 \rightleftharpoons CH_3OH \; ; \quad \Delta n = -2$$

N: 1—x 4—2x x

Again assume x mols CH_3OH formed. 2x mols hydrogen disappear, and x mols of CO disappear. Since 100 percent excess hydrogen is used, 4 mols of hydrogen per mol of CO are charged. Thus, 4-2x mols of hydrogen are present at equilibrium.

Thus, $N = (4 - 2x) + (1 - x) + x = 5 - 2x$

and, $\frac{K_p}{1} = 2.7 \times 10^{-4} = \frac{K_\pi \left(\frac{\pi}{N}\right)^{\Delta n}}{1}$

$$2.7 \times 10^{-4} = \frac{x}{(4-2x)^2\,1-x} \cdot \left[\frac{5-2x}{204}\right]^2$$

$$\frac{x(5-2x)^2}{(4-2x)^2\,(1-x)} = 1.22$$

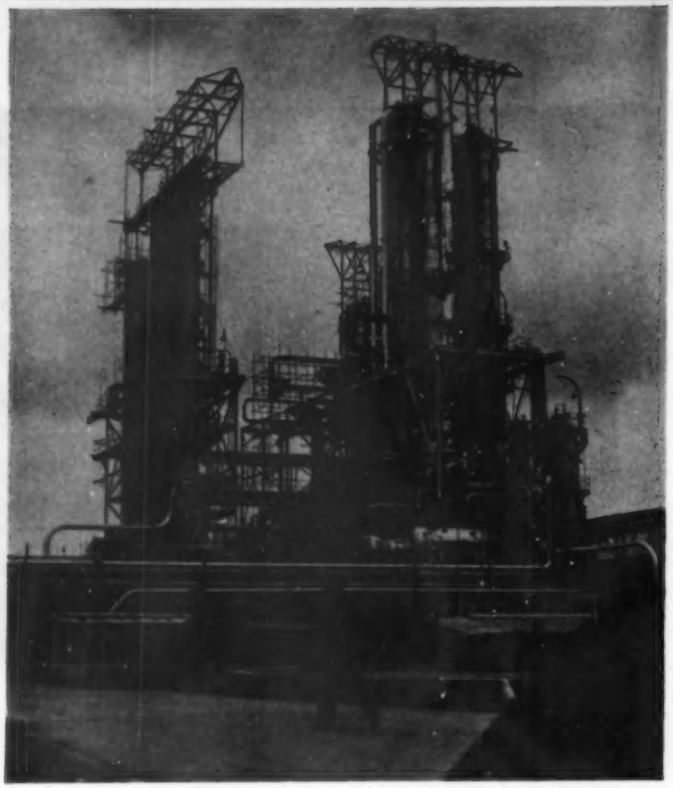
Solving assume $x = 0.415$

$$\frac{0.415}{0.585}\left[\frac{5-0.83}{4-0.83}\right]^2 = \frac{0.415}{0.585}\left[\frac{4.17}{3.17}\right]^2$$

$= 1.23 = 1.22$ for all practical purposes.

∴ **percent conversion CO to CH_3OH is 41.5. This compares to 29.5 for stoichiometrical hydrogen.**

End of Part I. Part II will appear in an early issue.



Second Distillation Unit Trebles Output

THE second distillation unit at the Shell Stanlow (Cheshire) refinery is now in operation, nearly a month ahead of schedule. This trebles the plant's capacity, bringing it to over 21 million barrels a year.

This refinery, which first came on stream in November, 1949, is due for completion in January, 1952. In addition to producing a comprehensive range of petroleum products, including high quality gasoline, gasoil, fuel oil, synthetic detergents and chemical solvents, it will also make full use of its refinery gases as raw materials for its own large chemicals-from-petroleum industry. Five further units are yet to be completed, including a catalytic cracker, on which work is well advanced. These installations will permit a variation in the output of refined products to suit market demands.

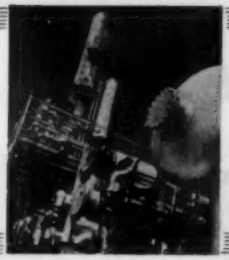
Recently, what is believed to be the biggest lifting operation of its kind in the United Kingdom was successfully carried out at Stanlow. A welded steel absorber column (weight 240 tons, length 170 feet, diameter about 10 feet) was raised to vertical by huge gauntries specially designed for this task. Its size may be gauged from the fact that, on the 225-mile journey from the manufacturers'—Babcock & Wilcox—works at Renfrew, Scotland, it had to be transported in three sections and subsequently assembled and welded on the refinery site.

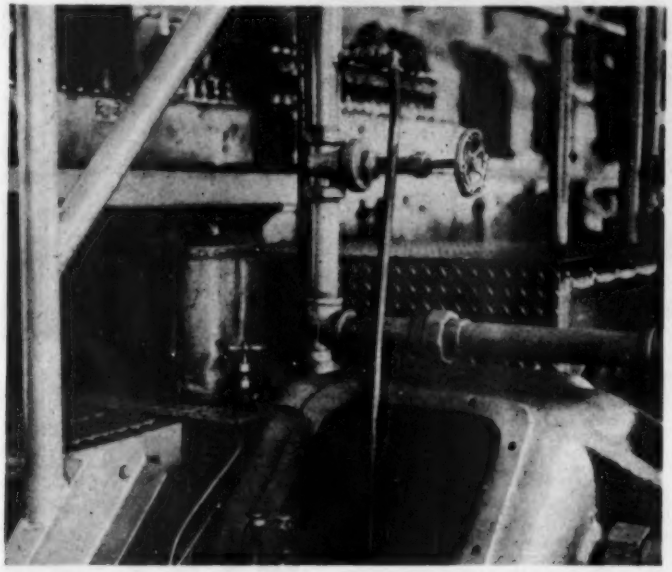
The new extensions at Stanlow form part of an $84 million postwar refinery expansion program that Shell has undertaken in Britain. This includes Stanlow's complementary refinery at Shell Haven, Essex, which is already in full operation, with a capacity of more than 14 million barrels a year, and a plant at Heysham, Lancashire, with a capacity of more than 10 million barrels a year. Another related project is at Pernis, near Rotterdam, Holland, where the refinery's capacity has recently been enlarged, enabling it to process over 28 million barrels of oil a year. These four refineries—Pernis, Shell Haven, Stanlow and Heysham—are strategically located to feed the Northern European market in the most economical way. Taking into account the refineries in France, Germany and Italy, Shell is now by far the largest refinery operator in Western Europe with a total annual capacity of some 140 million barrels.

Top of page picture: A View of the No. 2 Distillation Unit at Shell's Stanlow (England) Refinery.

At right: Welded Steel Absorber Column Being Raised into Vertical Position. In the immediate background is the refinery's concrete water cooling tower, termed the largest of its kind in the world.

MAINTENANCE And OPERATION How To Do It—





HOW TO—

Break in New Piston Rods and Packing Glands

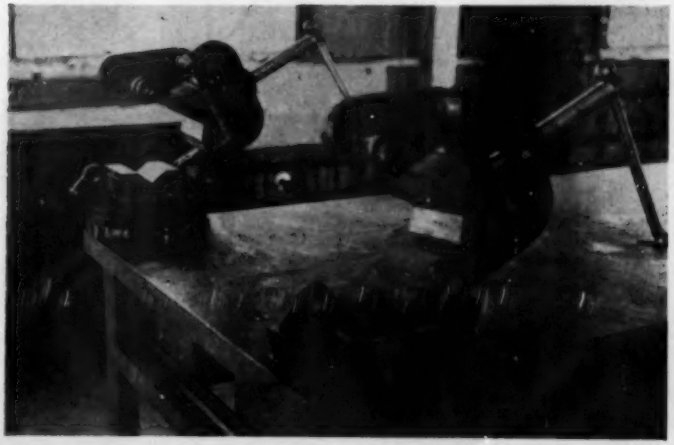
UNTIL new packing has been perfectly seated, packing glands and piston rods frequently run at higher temperature than desired for good operation. Break-in facilities have been provided on engines with water and excess oil. Water is supplied through a flexible rubber tube which guides the small stream to the point desired. The water is obtained from the jacket water cooling circuit. Oil is provided by a gallon can with dust proof cover. It is set on a step plate above the cylinder. A needle valve, for volume control, and a length of copper tubing, is attached to the container. The outlet of controlled oil volume can be directed to the piston rod near the packing gland.

HOW TO—

Make Efficient Vise For Clamping Polished Piston Rods

CLAMPING highly polished piston rods firmly for the removal of attached pistons and/or retaining nuts has always been a problem fraught with possible damage to the rod. One solution provides an interchangeable set of jaws for a heavy pipevise. The vises are bolted to the top of a substantial work bench. The original serrated jaws are removed and a similar set made in the shop of steel plate equipped with "V" block centers. A bronze surface is given to the faces of these new jaws by brazing. This relatively soft metal does no damage to the surface of the piston rods. Two vises installed on the heavy shop bench allow work with the least amount of lost motion.

If the nuts or piston are not too tight, clamping in the bare "V" blocks is sufficient. If the nuts are tightly screwed to the shaft, a sheet of fine sand paper is carefully wound around the rod before clamping in the vise. These vises are used to prepare the piston and rod for separation when a hydraulic press is necessary to remove the piston, and to reapply the nuts or retainers.

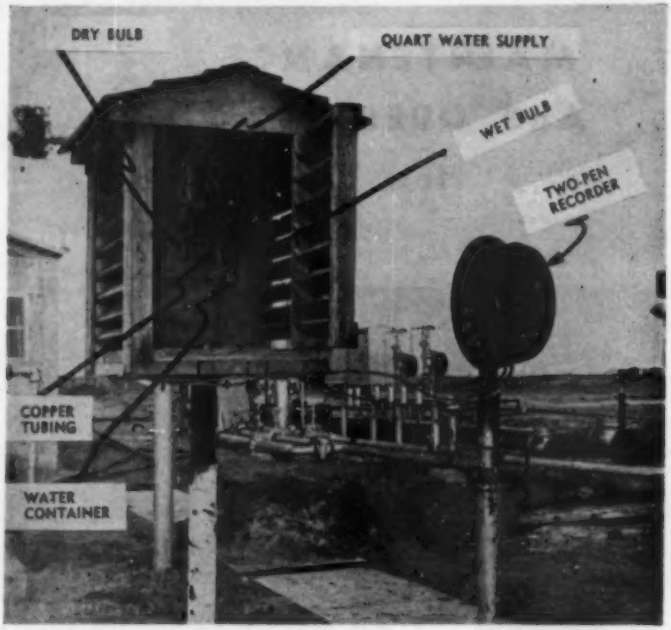


HOW TO—

Make Device for Wet and Dry Bulb Temperatures

FOR a daily record of the wet and dry bulb temperature, this device was made from a two-pen temperature recorder made surplus by plant process changes and some red wood scraps from a cooling tower. The two temperature bulbs are suspended in the house as illustrated. A quart sample bottle is filled with water and inverted to maintain a full water level in a small container. The wet bulb is covered with a soft piece of cloth that extends into the water container, so that the sensitive bulb is wet at all times.

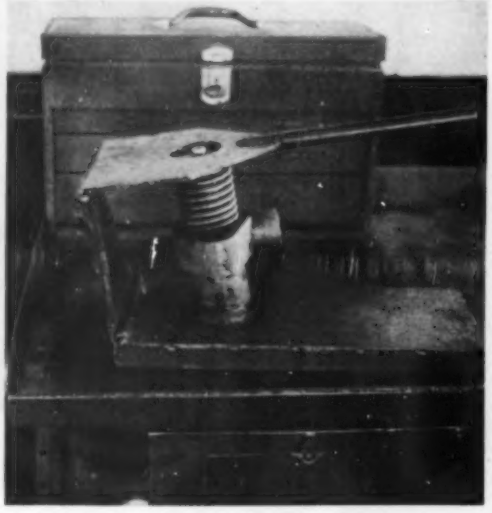
The two sides and the front of the house are louvered so that the wet and dry bulb temperatures are not affected by the sunlight, instead the actual temperatures are recorded both day and night.



HOW TO MAKE—

Valve Spring Compressors

COMPRESSING the springs of fuel injection valves without adequate precautions may result in injuries to mechanics. A valve spring compressor of simplicity can be made that will prevent keepers from flying loose, and will retain the spring safely in place while the valve unit is being disassemled, or again reassembled. The base of this tool is made of steel approximately 10 x 18 inches. Two sheets are used separated by a narrow bar of approximately 1½ inches wide. Welding is employed to join the parts of the base to form a thin unit so that a boss can be inserted the size of the outside of the seat end of the valve assembly. Two triangular pieces of steel form the hinge end. The top part, or lever, is a triangular section with a round extension handle.



This top part has a hole large enough to pass the stem and the keepers, but small enough to bear against the spring top retaining washer. Inserting the valve assembly in the compressor and removing the keepers is an easy operation that is accomplished with safety.

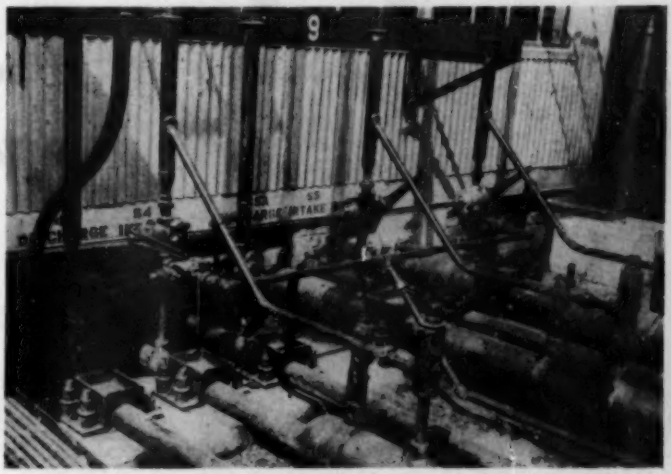
HOW TO—

Use a Carrying Case To Clean Lubricators

AS INDIVIDUAL pumps in force-feed lubricators require a certain amount of maintenance, repair and cleaning, the down time of the machine to which the unit is attached can be cut to a minimum by supply.ng spare pumps in the engine room for quick replacement. A tinsmith, can construct an adequate container to be carried from the shop to the engine room, or to any one of the engines where replacement of lubricator parts is required. A convenient container of a size to contain six spare pumps is fitted with a notched bracket for hanging the individual pumps. The case is made with the bot-

tom wide so that the open side slopes on an angle toward the narrow top section. A handle is attached for carrying. A stenciled sign indicates that the pumps are clean, repaired and ready for use. A similar case stenciled "Dirty Lubricators" is used for pumps which are to be returned to the shop for cleaning and repair.

fitted with other control valves near the vent stacks. This piping was led to a common line connection to a four-inch waste carrier so that no vapors are now released to stain windows and mar the painted surface of the engine room.



HOW TO—

Install a By-Pass For Compressor Vents

VENT stacks on the compressor manifold at one plant allowed the gas to escape to the atmosphere, but the force of the flowing vapors also carried any accumulation of other material into the air, which caused it to drop down upon roofs and windows. Operators with pride in the outward appearance of an engine room suggested that the vented gas be carried through by-passes into a pipe line leading to a flare at the extreme limits of the plant yard. Piping was connected to the vertical stacks below the vent control plug valves and

HOW TO PROVIDE—

Water Valve Insulation

AN INEXPENSIVE and convenient box containing insulating cork chips was constructed for Transcontinental Gas Pipe Line Company to protect water meters and above-ground water valves against freezing. The box was made of 2 x 4's, some 1 x 8 shiplap, and galvanized sheet metal. This installation has the advantage of enabling personnel to read the water meter and operate valves regardless of temperature conditions.

A 2 x 4 frame was built to enclose all the piping to be insulated. Top and bottom were left open. Holes were drilled in this siding to allow valve stems, etc., to reach outside the box. The sides were then covered with galvanized sheet metal.

A hinged top was made by nailing 1 x 8's on a rectangular 2 x 4 frame and covering with galvanized sheet metal. Care was taken to insure that this top fitted the box snugly and that the 2 x 4 rectangular lid frame would clear the inside top plates of the box frame when the lid was closed.

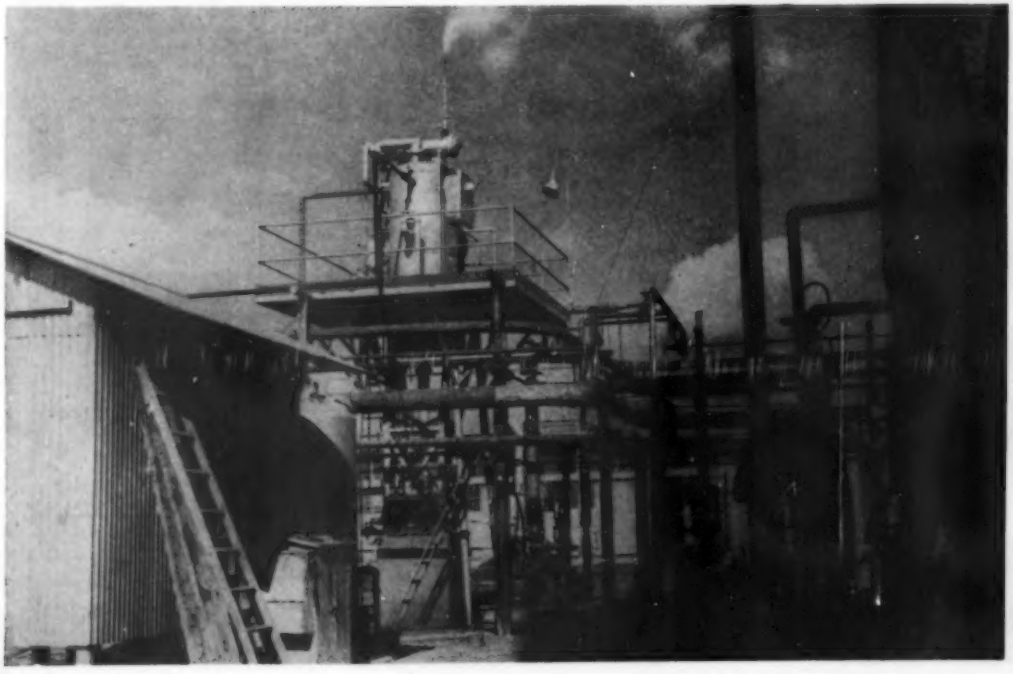
After the box had been painted and the valve wheels replaced, the cork chips were poured to a level slightly below the top of the water meter, as shown.

MAINTENANCE
And OPERATION
How To Do It—

Boiler feed-water heater showing deaerator elevated above standard height to insure suction on boiler feed pumps without "kicking off."

Boiler Feed Water Preheating At Terminal Island

THE PROBLEM that faced the operators of Wilmington Gasoline Company at Terminal Island, Calif., was to raise the temperature of the boiler feed water as high as practical, yet avoid the possibility of



Opposite side of feed water heater and deaerator showing arrangement of lines for condensate, fresh water and pump suction.

the feed pumps 'kicking off.' The complication was clear. The Terminal Island plant steam requirement was approximately 60,000 pounds of 125 psig. steam per hour for oil preheating and processing. Anything that might be done to increase the temperature of the feed water would automatically reduce the fuel requirements of the boilers. Unfortunately, with older types of feed-water heaters, the boilers could not be operated with a feed-water temperature high enough to meet requirements.

Modernization Steps

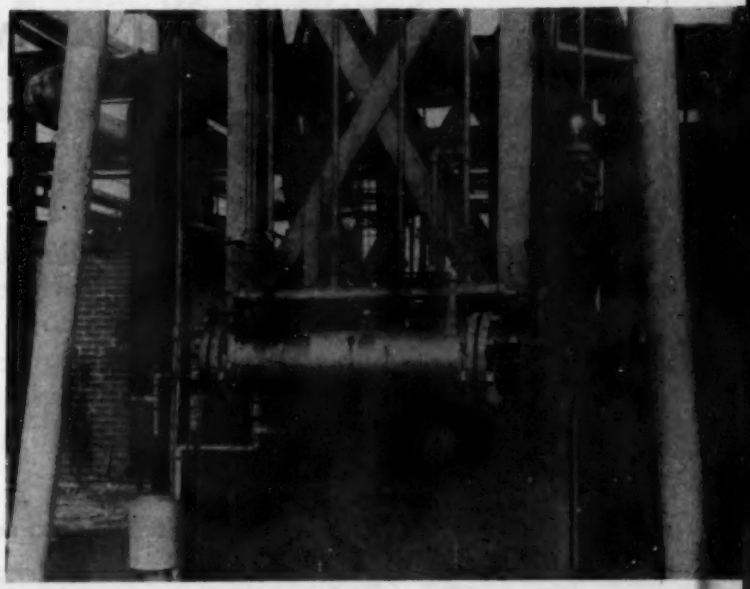
Early in 1951 steps were taken to modernize the Terminal Island plant and to reduce the demand for boiler fuel as much as possible. These included:

A feed water heater and deaerator was installed. Calculations indicated that the water level in the vessel should be at least 18 feet above the pump suction to handle water at an average temperature of 255° F. with a vessel pressure of approximately 6 psig. A platform structure and water tank support was made of pipe and structural steel. The vessel suport was installed on a concrete pier approximately five feet above ground surface at the pump setting. Legs of the platform supporting structure were set in excavations and grouted with concrete.

With the installation of a 6-inch suction line, the pumps have delivered the required quantity of boiler feed-water even under constant operation with feed-water temperature at 300° F.

Provisions were made so that representative samples of make-up condensate and boiler feed-water could be obtained for frequent laboratory inspection at a temperature low enough so that vapor loss could be prevented. A small tubular sample cooler, set in supporting strap hangers, is supplied with freshly treated make-up water as a coolant so that hot streams of sample water could be obtained safely without steaming. This small stream of cooling water is split from the fresh feed to enter the cooler and then travels to the overhead vessel without requiring a separate source of cooling water.

Another modernization was the installation of an automobile engine type oil filter in the pump section line near the feed unit. It was added to off-set the tendency of liquid chemicals to foul the check valves of the suction and discharge lines of the motor-driven lubricator-type pump which treated the boiler feed with solutions. The conventional element commonly used for oil-filtering and clarification proved sufficient for this job because the amount of suspended matter in the treating solution is small. Under operations to date the automobile filter has maintained a clean stream to the pump and not one check valve has fouled up, nor one cartridge needed replacement.



Sample unit through which feed water, condensate, make-up and composite samples can be obtained through water cooled condenser.

Conventional crank-case oil filter installed on chemical pump suction to remove any suspended matter which had been fouling check valves.

"OPERATION SAFETY"

W. A. SULLENDER
Pan American Refining Corporation, Texas City, Texas

Temporary Platforms:

Accident files are crowded with sad reports saying "the barrel I was standing on just turned over". The doctor's report, which concludes the episode, cryptically notes (in the usually illegible longhand) comminuted fracture medical epicondyle, left; crushed astragalus, right; or oblique fracture left femur, compounded. To the victim these hurt exactly like a broken arm, broken foot, or broken leg. They are.

Always have a **substantial footing** and a **secure platform** when you are going to tug or strain on any job. And note in advance where you are going when the wrench slips.

Witless Willie, shown at work at left, is no doubt thinking about the exact wording he is going to use on his next accident report.

Continuous Molding of Paraffin Wax Is Effected

L. H. JENNINGS, J. H. BEARD and V. A. KALICHEVSKY
Refining Division, Magnolia Petroleum Company, Beaumont, Texas

BATCH WAX molding processes long used in the majority of our refineries having wax production, have certain inherent difficulties that have troubled the operators of the rather primitive conventional equipment.

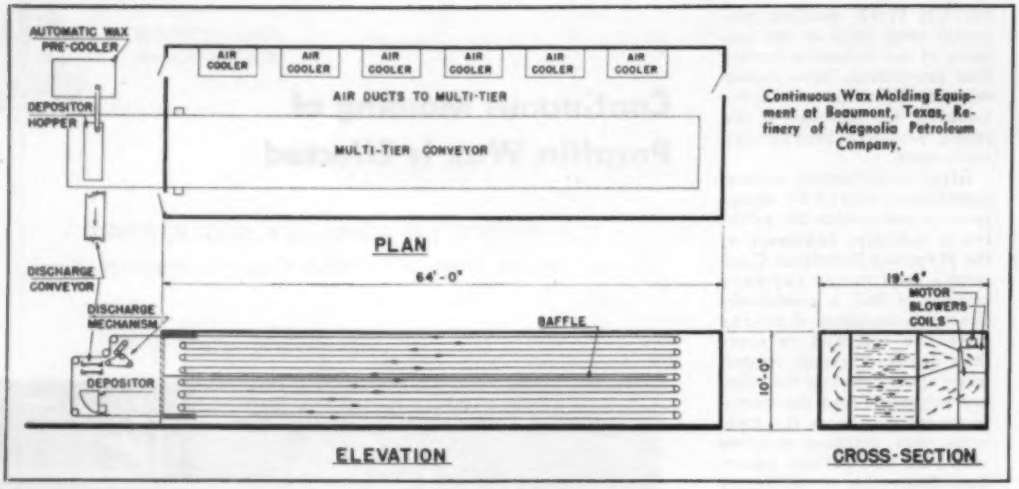
After investigating various possibilities offered by equipment in use outside the petroleum industry, engineers of the Magnolia Petroleum Company's Beaumont refinery concluded that a continuous chocolate-molding machine might be modified to serve their needs. Through cooperative effort between the refinery engineers and the manufacturer's engineers, a continuous wax molding machine was built and put into operation. This rather revolutionary process is expected to have considerable impact upon our industry. The article published here was first presented before the Wichita, Kansas meeting of the Western Petroleum Refiners Association in July of this year.

FOR many years paraffin wax was regarded as a surplus product of little value to refineries and was normally disposed of as a cracking stock. Only a small portion of the mineral waxes, necessarily manufactured in the normal refining processes for gasolines and oils, ever found commercial outlets, and what little wax was sold was utilized mainly as an adulterant or as a cheap substitute for vegetable and animal waxes.

Today, however, continuously advancing knowledge of the nature of mineral waxes and modern wax manufacturing techniques have resulted in a tremendously increased popularity for products made from petroleum wax. Then too, petroleum waxes have won new outlets on their own merits and the wax industry as a whole has acquired a present important position in industrial and home life.

The rapid growth of the industry may be visualized from the fact that the total quantity of petroleum waxes which will be produced in this country in 1951 will easily pass the one-billion-pound mark, and represents an increase of some 30 or 40 percent over the last decade. Considerably more than one-half of this figure will be represented by paraffin waxes of various melting points. Close to three-fourths of these waxes will be consumed for processing paper, while the rest will be utilized in candle and electrical insulation manufacture, in

NEW ↑ Above: Continuous Wax Molding Unit, Remote Control Operating Panel in Center. Below: Conventional Batch Molding Process. ↓ OLD



Continuous Wax Molding Equipment at Beaumont, Texas, Refinery of Magnolia Petroleum Company.

the textile, leather, cosmetic and lumber industries and in the formulation of polishes. These varied uses also explain the necessity of supplying a widening market with more than one grade of wax.

Paraffin wax is usually sold by refineries in the form of cakes, which vary in size, depending upon the available molding equipment and the wishes of customers. These cakes are frequently referred to as slabs of wax.

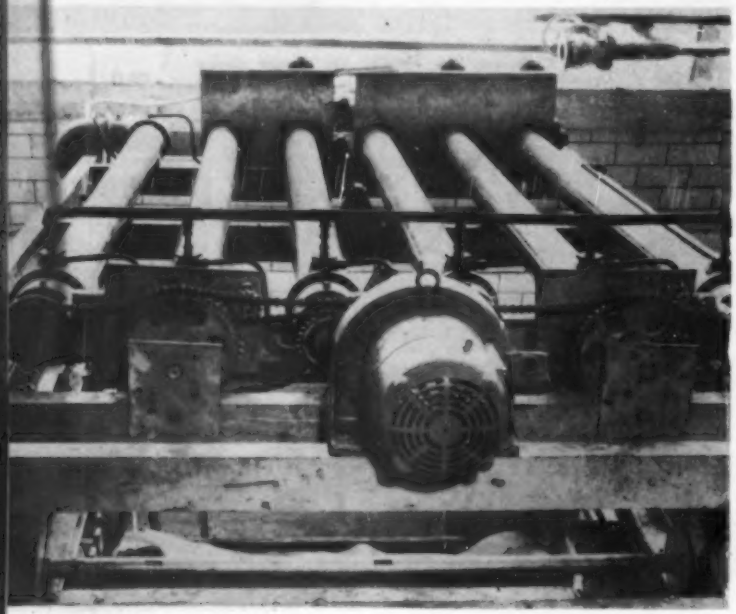
Old Batch Method

While wax processing methods have steadily improved, wax molding techniques have remained practically unchanged from the batch molding method first used by the industry. Conventional equipment is still represented by a modified plate and frame press with molds and cooling plates substituted for rings and filter plates.

In this batch method the sides of the molds and the plates project about three inches above the top when the press is assembled. The upper portion of the system resembles a long pan with openings at the top of each mold. The molten wax is pumped into a tank from which it gravitates into the pan and through the openings into the molds. The wax is always at atmospheric pressure and the pressure from the press is applied only for holding the plates in place.

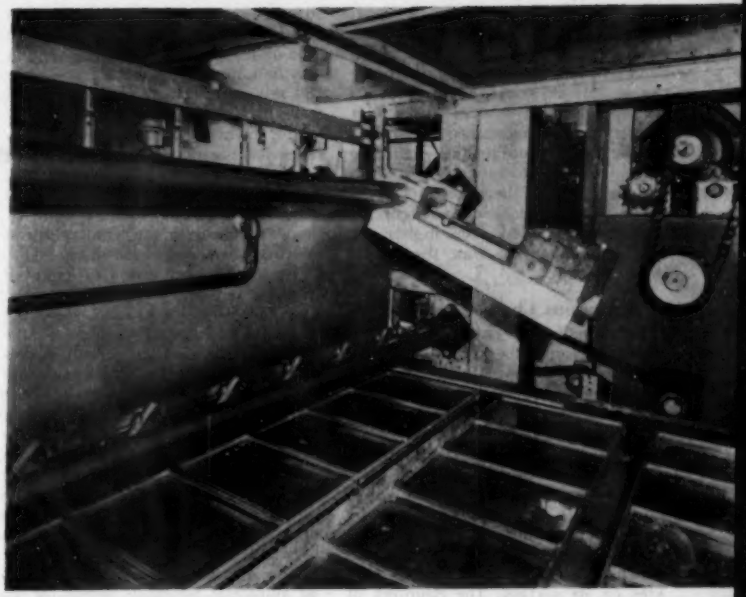
After the molds are filled, water is circulated through the cooling plates. A layer of liquid wax is maintained in the pan while the wax solidifies. This is necessary because of the uneven shrinkage of the wax cakes which undergo a 15 to 17 percent contraction from a liquid just above the melting point to a solid at room temperature. During the solidification process, heat is sometimes applied to keep the wax in the pan liquid, thus insuring its easy flow into the molds to form relatively uniform cakes. The cooling period lasts from two to three hours depending upon the melting point of the wax and the temperature of the cooling water. After the cakes are formed, the surplus wax remaining in the pan is scraped off, the press is opened, and the cakes removed manually.

This brief description of the batch molding process suggests the many inherent difficulties encountered by refineries in operating this rather primitive conventional equipment. The process is slow and expensive, requiring a great deal of manual work. The cakes are often uneven and vary in weight because of the difficulty of maintaining a continuous flow of wax into the moulds during the solidification period and the presence of entrapped air. After the cakes are formed, some wax is lost in scraping off the surplus left in the pan. The necessity of scrap-



Tempering Exchangers for Equalizing Temperature of Molten Wax.

Pans Filled with Wax Moving to the Cooling Chamber. →



ing the wax also makes the process sloppy, and the floor area required to accommodate batch equipment is comparatively large.

The shortcomings of the batch molding process instigated work by the engineers of Magnolia Petroleum Company to develop improved methods for manufacturing wax cakes. After investigating various possibilities offered by other than petroleum industries—all of which offered somewhat similar problems as those in the batch molding system—the engineers decided that the continuous chocolate-molding machine sold by the J. W. Greer Company, Cambridge, Massachusetts, might be properly modified to offer a solution to the wax-molding problem. Through the joint efforts of the two companies, a continuous wax-molding system was built and put into operation at the Beaumont, Texas, refinery of Magnolia Petroleum Company.

New Continuous Method

The schematic flow diagram of the process shown in the accompanying illustration reveals the simplicity of this new continuous method for molding waxes. Here briefly is how the system works: First, molten wax kept in insulated and steam-heated charge tanks is pumped through automatically controlled "tempering" exchangers where its temperature is adjusted somewhere between 140 and 160° F., depending upon the wax melting point. For best performance this temperature should be as low as possible, provided the wax does not begin to solidify before it reaches the cooling chamber. The tempering exchangers are designed to operate both as heaters or coolers in order to maintain an even temperature of the wax stream regardless of the temperature of the wax in the storage tanks.

From the tempering exchangers the liquid wax is directed to the steam jacketed "depositor hopper." This hopper is an open rectangular tank with a partially sloping bottom. The wax level in the hopper is automatically regulated by controlling the speed of the charge pump. The portion of the hopper having the flat bottom contains six pistons which act as measuring devices for the quantity of wax required to form the individual cakes. The pistons are easily adjustable, having a maximum ability to discharge 12 pounds of wax into each pan. After the pistons are set, the weight of the wax delivered into the pans remains constant and varies less than one-half of an ounce between the individual fillings.

The pistons discharge the molten wax directly into the molding pans which are 19 inches long, 11¾ inches wide and 2 inches deep. In continuous circulation are 2508 such pans. The dimensions are not critical although they are somewhat limited by the overall equipment specifications for the individual installations. Considering the minimum permissible thickness of the wax cakes due to their brittleness, the pans of the above size can accommodate from 8 to 12 pounds of wax. The molding pans rest on trays which move on a chain conveyor. Each tray holds six pans corresponding to the 6 pistons from which the molten wax is discharged.

After the pans are filled with the wax, the trays carry them through cooling compartments where the solid wax cakes are formed. Cooling is done by a stream of cold air supplied perpendicularly to the direction of tray travel. Cold air is obtained by passing the air over 5 dry coil carrier evaporators connected to a 150-ton ammonia compressor.

The cooling chamber is completely

Positive Displacement Pistons for Discharging Wax into Cooling Pans.

enclosed and insulated to insure maximum operating economy by recirculating air within the system. For maximum output the refrigerating coils are run at full capacity and the blowers are operated at constant speed. Air temperature is maintained at 20°-30° F. The rate of cooling the wax cakes is controlled automatically by varying the speed of the conveyor; it depends upon the melting point of the wax to be molded. The higher the melting point of the wax, the greater the unit output.

Ingenious Chain Conveyors

Construction of chain conveyors passing through the cooling chamber deserves further description because of their ingenious design. After the conveyor reaches the opposite wall of the cooling chamber, the trays are automatically lifted and transferred to the next higher level of the same conveyor to move in the opposite direction. This is done without disturbing even to the slightest extent the partly solidified wax in the molding pans which would result otherwise in wrinkles on its surface. The doubling of the conveyor may be repeated as many times as desired, contributing to the compactness of the design by substituting height for length of the cooling section. In the Magnolia installation the trays make 14 passes through the cooling section, traveling a total distance of about 800 feet in a space 64 feet long and 10 feet high. The entire molding unit is driven by one 10-horsepower motor through a variable speed reduction gear. The residence time of the wax in the cooling section may be adjusted anywhere from 60 to 180 minutes by varying the speed of the main drive gear.

The surface temperature of the wax cakes leaving the cooling chamber is controlled between 60° and 80° F., depending on the melting point of the wax. The lower the melting point of the wax, the lower the temperature at which the wax cakes are discharged.

The wax cakes are also removed from the molding pans automatically. The pans which are attached to the trays are tilted until they are in the upside down position and the cakes drop from the pans. The chain conveyor makes another turn and the trays and pans assume their former positions. The bottoms and sides of the empty pans are heated slightly by passing the trays over an electric heater before starting the next traveling cycle through the system. The wax cakes dropped from the pans are picked up by a belt conveyor.

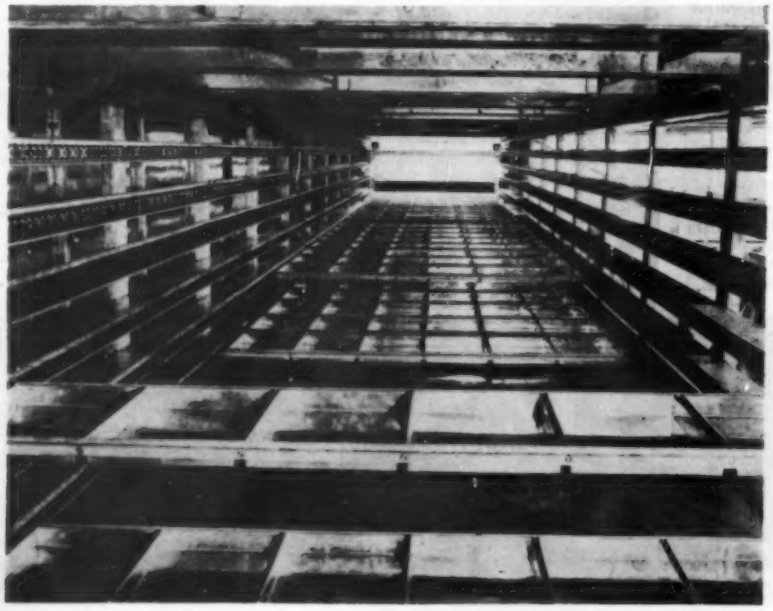
The original installation included an automatic weighing device for inspecting the wax cakes. However, this device was soon found to be superfluous because the individual cakes vary less than one-fifth of one percent by weight from the average. In the conventional batch molding process, cakes of similar sizes varied in weight by as much as five percent.

The equipment, which has been installed by Magnolia Petroleum Company is capable of molding from 11,000 to 17,000 pounds of wax per hour, again depending upon the wax melting point. The wax cakes are exceptionally uniform in size and have a bright luster appealing to the eye. No wax is slopped except at the very beginning of the operation while the equipment is brought up to equilibrium conditions. This slop wax is returned to a special melting tank for reprocessing.

The labor requirements per unit weight of molded wax produced was reduced five times as compared with the conventional batch process and further savings are in sight. The larger the volume of the wax molded, the greater the savings in manpower.

The appearance of the conventional wax-molding rooms with the wax spilled on the floor and equipment is practically eliminated. The floor space required for accommodating the equipment is not over one-tenth of that normally occupied by the wax-molding presses and may be further reduced, if desired, by increasing the height of the cooling chamber.

The new continuous process is also well adapted for automatic packaging of wax cakes into paper boxes and discharging these boxes directly into the freight cars. This makes the process highly desirable from the sanitary point of view, because handling of wax or wax cakes by hand may be completely avoided from the time the crude oil is obtained by the refinery until the finished product is delivered to the customer.



Cooling Chamber under Construction Showing Position of the Lower Rows of Trays and Pans. This is part of new continuous wax molding installation made by Magnolia Petroleum Company at its Beaumont, Texas, plant.

Supports for Vertical Pressure Vessels

PART II

F. E. WOLOSEWICK
Structural Engineer, Chicago

PRESSURE vessels in process plants are subjected to varied conditions of operating temperature and pressure. The operating temperatures may be anywhere from extreme low levels to the maximum that construction materials will permit. Pressures may be high vacuum or several thousand pounds per square inch, or anywhere between. Vessels when placed in service or shut down commonly undergo large changes in temperature or pressure, or both. These changes induce stresses in the support structures through variations in expansion between support and vessel. Such stresses may on occasion be quite large.

Comparatively little information has been published on this important subject, and this study will be welcomed by the industry.

This second part of a four-part series will be followed by part three in an early issue of PETROLEUM REFINER. Part I appeared in the July issue.

DUE TO mathematical difficulties of setting up formal elastic equations correlating displacements in differential forms for multiplicity of varying loads, symmetrically arranged around the circumference, recourse is generally made to a simpler method of attack. It is difficult at present to utilize the empirical equations developed by Roark[1] to stress determinations from lug concentrations, although some uncompleted studies under way, indicate a possibility of their utilization.

In discussions which follow, it is assumed that the ring action of the shell will carry the entire system of loadings imposed by lugs, without the benefit of restraint by longitudinal fibers of the vessel.

This assumption is one of convenience, used to avoid the mathematical difficulties associated with theory of elasticity. The results are obviously on the safe side to what extent, is somewhat problematical. The results of this analysis give equations which are easy to apply when plotted. They have been used for a reasonable period of time for various vessel diameters under high temperatures and lead to practical and economical designs. They show up somewhat unfavorably when applied to thin wall vessels of large diameters. For such limiting cases several methods of approach are possible.

The portion of the vessel where concentrations are anticipated could be provided with a much thicker wall, capable of taking flexural stresses due to concentrations. The lugs may be increased in height, thereby decreasing intensity of lug pressures. The variation is roughly a linear one. Or the number of lugs could be increased sufficiently to bring moments within reason, and by suitably spreading the ribs in the lug itself, further reduction in moment is possible. Addition of circular stiffening ribs, either partly or fully around the diameter of the shell is helpful, and quite economical. Detailed study involving combinations of the above, is another possibility.

Basic Considerations

In the analysis which follows, the ring action of the shell is assumed to carry all of the load due to flexure. The conventional hypotheses of strength of materials are used as follows:

1) Stress in the ring is assumed to be a linear function across the thickness of the shell. This assumption is modified by plastic deformation, in which case, the triangular stress distribution would be replaced by a parabolic one. The limiting case from practical stress evaluation would be a rectangular stress area. Undoubtedly under higher temperatures such distribution should be anticipated.

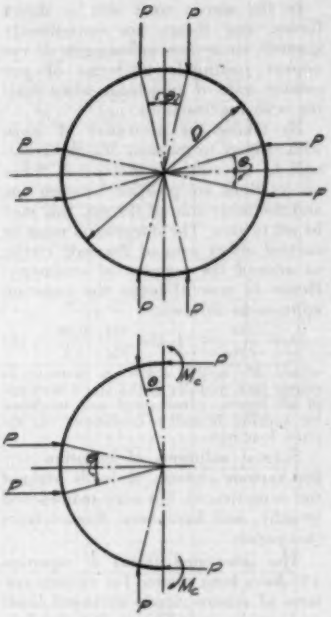


Figure 4

2) Modulus of elasticity in tension and compression are the same. This convenient assumption may or may not be strictly correct at elevated temperatures.

3) Elementary fibers behave freely, that is they are not restrained by longitudinal fibers of the vessel. This condition should be modified by multiplying the final stresses by $(1-v^2)$,[2,3] where v is Poisson's ratio. Under normal conditions of v of 0.3, this would represent a stress reduction of nine percent. With increase in temperature v decreases,[4] reaching a value of 0.25 at 600°, and then gradually increases to 0.35 at or about 900°. This would represent a stress reduction of 12 percent at 900° F.

4) Plane section before bending is plane section after bending, that is, there is no warping of the cross-section.

5) The law of superposition of stress is valid.

Development of General Equations

For any system of concentrated loads, symmetrically arranged as shown in Figure 4, the only unknown force is the bending moment M_C acting on the center line of the cut section. The horizontal reaction can be evaluated from statics, while the vertical reaction is either zero, or it also can be determined from statics and symmetry.

To determine the unknown force M_C it is easiest to use Castigliano's Theorem.[5] The general equation for work is stated below, and represents the effects due to bending:

$$W = \int \frac{M^2 ds}{2EI} \qquad (7)$$

In the above, work due to direct forces, and shears are conveniently ignored, since these refinements do not appear justifiable in terms of our present state of knowledge when dealing with lug reactions.

By taking the derivative of work with respect to moment M_C, the result will be the slope at that point. Since no rotations are possible between one and the other side of the cut, this may be set to zero. The integration must be carried either around the half circle, or around the segment of symmetry. Hence in general terms the equation appears as follows:

$$O = \frac{\partial W}{\partial M_C} = \int M_x \frac{\partial M_x}{\partial M_C} \frac{R d\theta}{EI} \quad (8)$$

where M_C is the unknown moment at center line, and M_x is the static moment of all forces, constrained and modified by specific boundry conditions of applied loadings.

Formal solutions of equation (8) for various systems of loads are not too complicated, but very tedious and lengthy, and have been deleted from this paper.

The integrated forms of equation (8) have been plotted for various systems of symmetrically arranged loads and are shown in Figures 5, 6 and 7.

A generalized equation for moment M_C for any system of equally arranged loads is listed below:

$$M_C = PD \left[\frac{n}{2} \frac{(\cos\Theta + \Theta \sin\Theta)}{\pi} - \frac{\sin\Theta}{2} - \frac{1}{2} \cot\frac{\pi}{n} \right] \quad (9)$$

when n = an even number of lugs Θ is the angle between the load and axis of symmetry, and must be expressed in radians.

The charts are based on a variable angle Θ. It will be observed that by decreasing the included angle Θ, moments on center line begin to increase, while a gradual increase of the included angle decreases these moments.

Recognition of reduction in moments due to spread of ribs can result in a more favorable stress distribution in the vessel, thereby reducing and minimizing stress concentration effects. In many instances, three to five degrees increase in angle Θ can bring resulting stresses well within those specified by the code. This variation should be recognized, as it leads to a more safer vessel.

The manner in which moments vary along the circumference can be determined from statics. Knowing the moment at the center line of the lug, together with the direct forces, H, and V, it is only necessary to take moments of these forces along circumference of the shell, or along the segment of symmetry. Through symmetry, moments in other segments would be the same.

A typical bending moment diagram, showing the variations of moments for four symmetrically arranged loads is shown in Figure 8.

Conditions frequently arise, where either due to the design of a particular type of lug, the pressure from the lug is uniformly distributed over certain area. Two such equations have been solved and are shown in Figures 9, and 10.

Vessel Reinforcement

Due to probable scarcity of materials, and for economic reasons, it may be necessary to resort to the use of discontinuous reinforcements around overstressed zones. Such discontinuous reinforcing has the advantage of minimizing stresses due to continuously applied rings.

Equations have been developed for two, four and eight load concentrations, and are shown in Figures 11, 12, and 13. These equations have as parameters, the limiting angular spread of additional reinforcement,

Figure 5

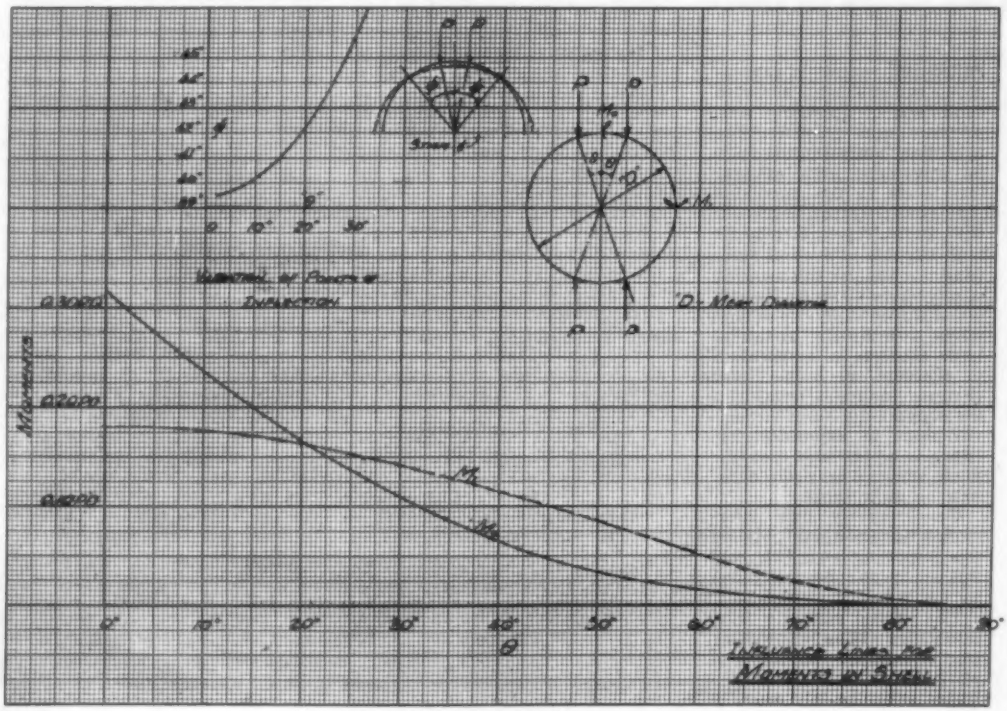
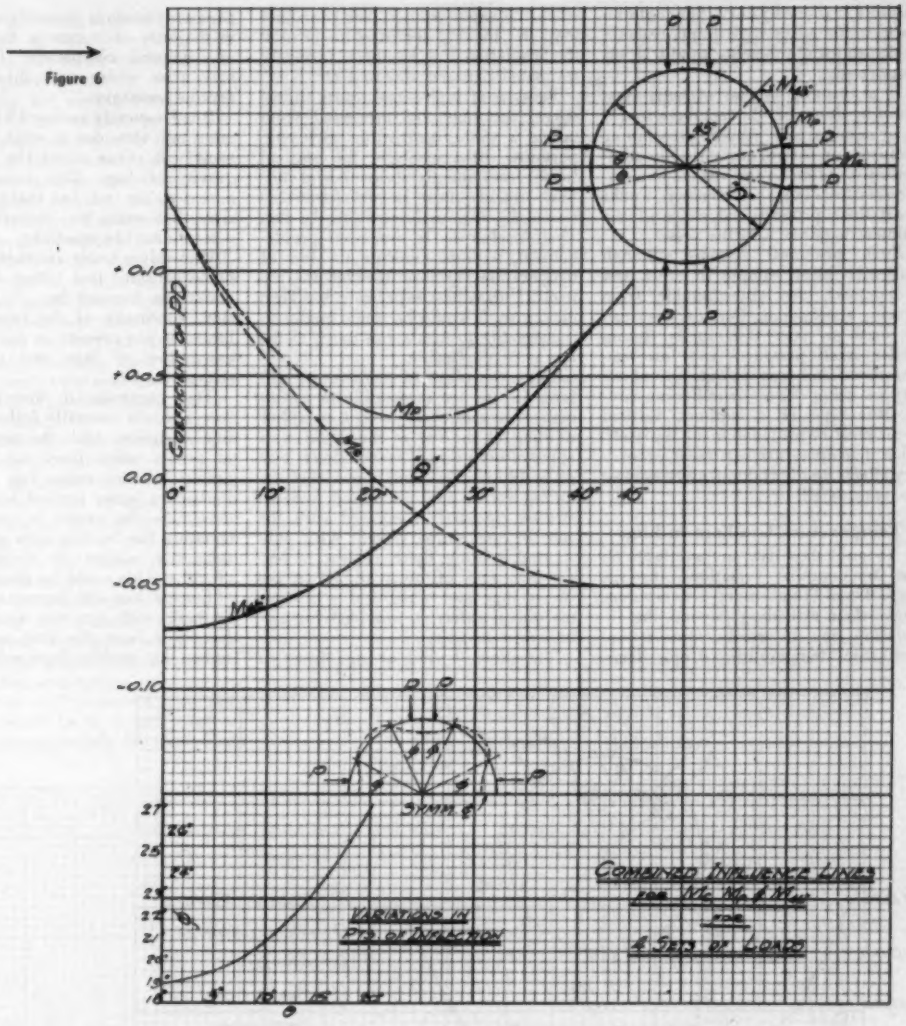


Figure 6


+0.10
+0.05
0.00
-0.05
-0.10
0°
10°
20°
30°
40°
45°
Mφ
Mθ
Mφθ
P
P
P

unstable if pinned joined, but could be made stable when rigid joints capable of transmitting moments would be incorporated.

If a framing system of such type could be designed, the members would be of nominal size, resisting tension or compression forces, and virtually eliminating bending in the vessel. For differential loading, such members would resist their proportional share of the moment together with the vessel.

Such structural systems although statically ideal, simple to erect and economical, are objectionable from process standpoints. Perhaps they can be used on very thin shells, acting under small pressures and low temperatures, and may obviate the necessity of using skirts, or stiffening ribs. In this type of a support, vertical shear must be provided in the lug itself. Also if temperature is present, secondary effects on the framing systems must be considered.

Temperature Gradient in Lugs

No published data are available on the temperature variations through lugs. From fragmentary observations, lugs when extending beyond the insulation line of vessels, show a considerable temperature drop. Thus, when the vapor temperature is around 900° F., the lug temperature beyond the insulation line has been variously estimated between 200 to 300° F.

Because of high temperature differences, the lugs are prevented from taking a shape compatible with temperature differences by the vertical loads. Undoubtedly shearing and flexural stresses must be developed between the various laminas in the lug. Their evaluation is somewhat problematical, without knowing the law of temperature variation through the lug itself. Unless past experience has been otherwise, it would be sound engineering practice to insulate as much of the lug as is practicable.

Since the effect of temperature differences are not susceptible to mathematical treatment at present, complete welding of the lug to the vessel wall appears desirable. The additional cost of welding over and above that required for normal shear and moment stresses, is small compared with the cost of the entire vessel. With substantial welding, there seems to be better assurance of unity of action between lugs and wall, and a greater margin of safety is provided for any unknown stresses.

The effect of wind, or pipe thrust on pressure vessels is generally small, and in majority of instances, their effects are ignored completely. Conditions may arise where such investigations may be necessary.

It is frequently assumed when evaluating bolt sizes due to wind, that rotations will occur about the center of gravity of lugs. This assumption is a reasonable one, for evaluating bolt sizes, but seems too conservative for determining lug reactions.

Probably a better assumption would be to consider that tilting will occur about the leeward lug. By construction, continuity of the type used in beams is not present in discontinuous assemblies of lugs and supporting structures.

The conventional distribution of forces would normally follow straight line variation, with the neutral axis at points other than the center of gravity of the entire lug assembly. Perhaps a better method would be to determine the center of gravity, by equating the bearing area of the leeward lug, against the resisting areas of bolts. This could be done by trial.

For two lugs 180 degrees apart, both methods will give the same results. For four lugs, the first method assumes that middle lugs will be inac-

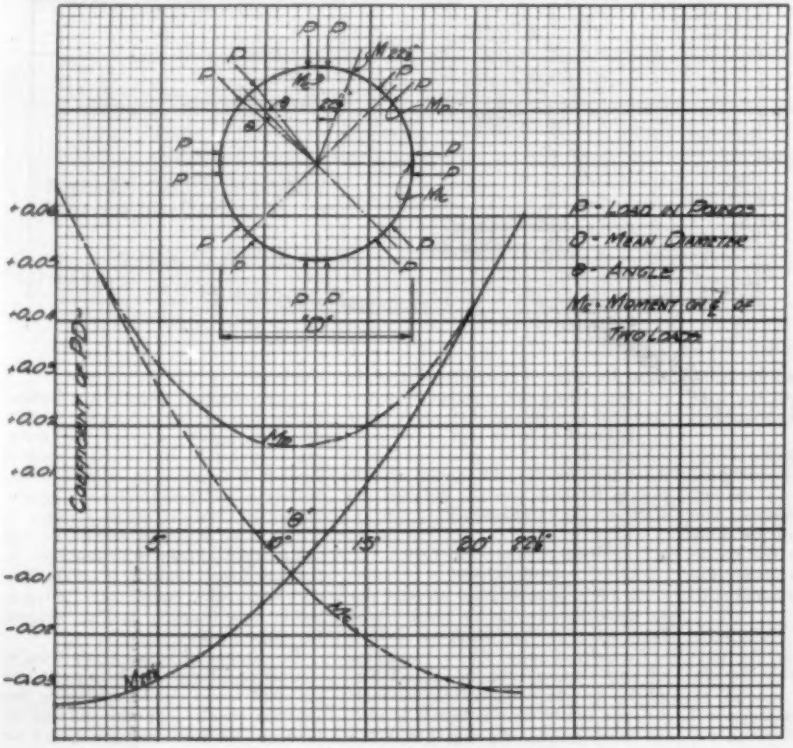


Figure 7. Combined Influence Lines for M_c, M_θ, and $M_{\theta\ 1/8°}$ for Eight Sets of Loads

tive, and the same resistance against overturning as with two lugs. This does not appear to be consistent with practical observations.

By using the second method, the resistance of the middle lugs will be some proportionate part of their distance from the neutral axis. Hence considerable amount of resistance is offered against tipping, and as a consequence, reactions due to wind would be considerably reduced.

In order to obtain statical equilibrium the sum of tensile pulls in the bolts, must at all times equal to the sum of vertical compressive loads of all lugs, on the leeward side of the neutral axis. Likewise their moments must be equal to the assumed moments due to wind. These are basic requirements of Statics.

It is assumed in this discussion that anchor bolts are sufficiently loose, in order not to hinder diametral expansion of vessel, and so minimize torsional effects on supporting beams.

It is not possible at present to determine exactly the stresses in pressure vessels due to unsymmetrical loadings. The chart which is shown in Figure 15, is based on two reacting loads, and the uniformly distributed wind is acting in line of action with the applied forces. This assumption may be too conservative, and perhaps a much better one[2] would be to assume that reacting forces uniformly distributed are

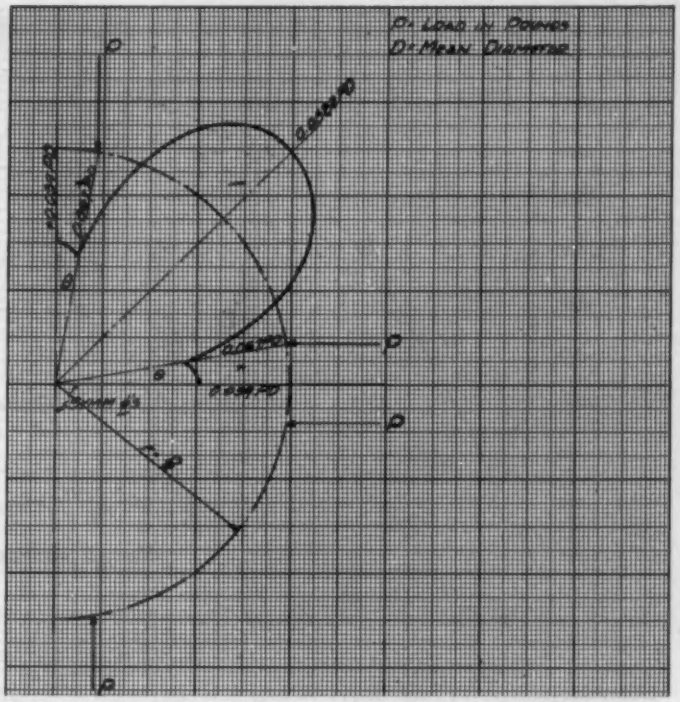
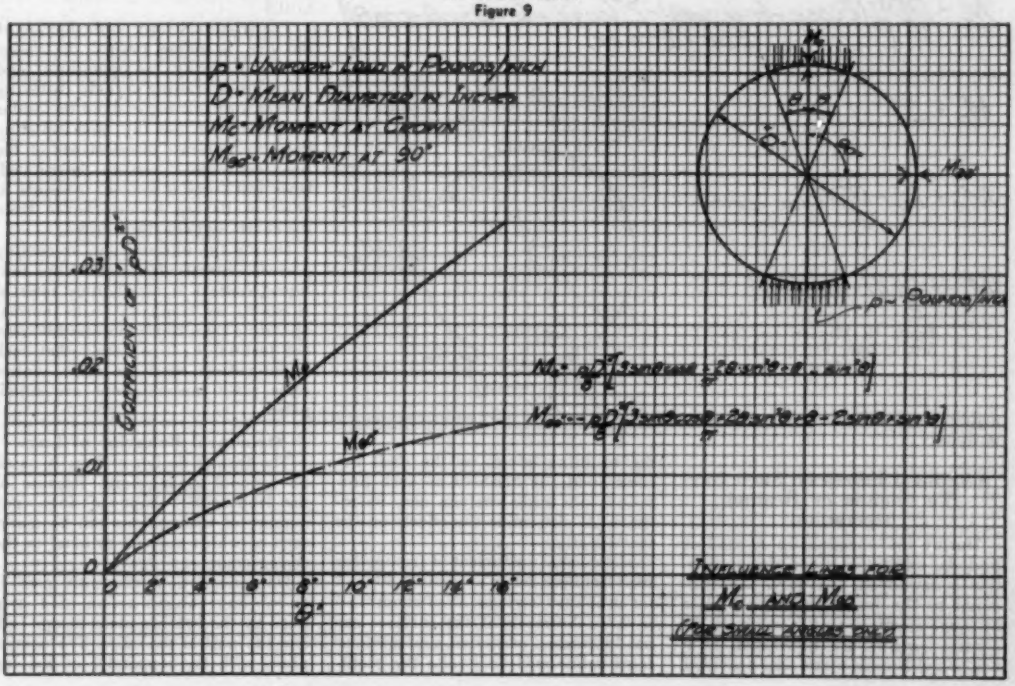


Figure 8. Moments in Shell. $\Theta = 10°$. Scale = 60. Four Sets of Loads.

Figure 9



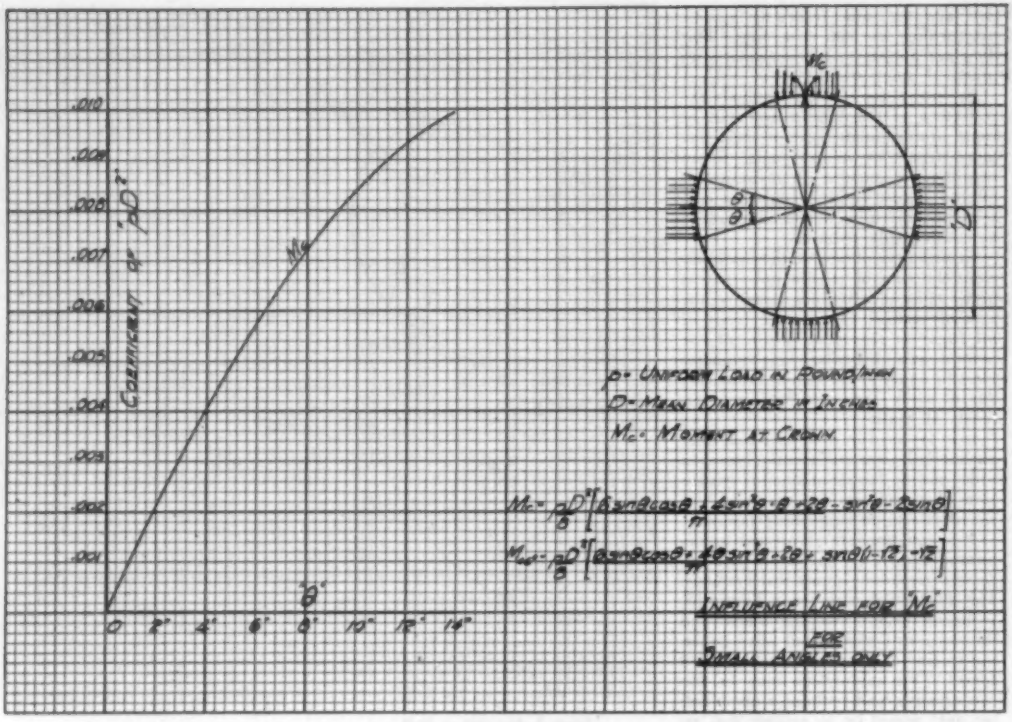


Figure 10

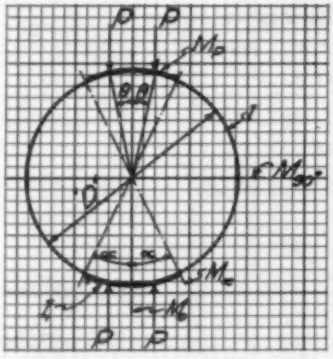
$$M_c = \frac{PD}{2}\left[\frac{I_1(2\cos\alpha - \pi - \alpha)\sin\theta) - 2I(\cos\alpha + (\alpha-\theta)\sin\theta - \cos\theta)}{2I\alpha + I_1(\pi - 2\alpha)}\right]$$

$$M_p = M_c$$

$$M_\alpha = M_c - \frac{PD}{2}(\sin\alpha - \sin\theta)$$

$$M_{90} = \frac{PD}{2}(1 - \sin\theta) - M_c$$

Figure 11. Moments for Two Sets of Loads with Reinforcing Plates



acting tangentially around the entire periphery.

Additional Forces on Shell Due To Cooling or Heating Operations

During the warming up or cooling periods, additional force due to friction is developed. This force would be equal to the lug reaction multiplied by some coefficient of friction. If the contact surfaces are lubricated, or if trepanned bronze plates are provided, the resulting effects on the shell become small. If however no such provisions are made analysis may be required to determine the effects on the vessel wall.

The normal coefficient of friction for steel has been set at or about 0.30, and for graphited surfaces at or about 0.10 to 0.15. Normally if the surfaces are not lubricated, corrosion, and accumulated grime may well raise the coefficient of sliding friction as high as 0.4 to 0.5

The frictional force at the bottom of the lug, is acting toward the vessel during warming up operations, and away during cooling periods. By taking moments of this force about the center of gravity of the lug, and equating these to moments of resistance of the lug, the force P can be determined. Once this force is known, moments in vessel walls can be determined from the charts and equations listed.

During the warming up, or cooling periods, operating pressures are low, liquid content is small, time interval is short, as compared with normal operating runs, hence increased stresses are justifiable. It is rarely that such investigations need be made, unless some plant misoperations are anticipated.

Structural Behavior of Lugs

The formal design of lugs is based on rational assumptions. Because of the trapezoidal shape of lugs, any number of assumptions can be made, each of which appears rational to the design engineer.

One assumption frequently used is to consider column action of a strip fixed by the bearing plate, at one end, and the wall at the other. The contact plane with the remainder of the lug

$$M_c = \frac{PD}{2}\left[\frac{I_1\{(4\cos\alpha - 4\alpha\sin\alpha - (\pi - 4\alpha)\sin\theta - \pi + 4\alpha) - 4I[(\cos\alpha - \alpha\sin\alpha - \cos\theta + (\alpha - \theta)\sin\theta + \alpha)}{4I\alpha + I_1(\pi - 4\alpha)}\right]$$

$$M_D = M_c + \frac{PD}{2}(1 - \cos\theta)$$

$$M_\alpha = M_c + \frac{PD}{2}(1 - \cos\alpha - \alpha\sin\alpha + \sin\theta)$$

$$M_{45^\circ} = M_c + \frac{PD}{2}(1 - \sqrt{2} + \sin\theta)$$

Figure 12. Moments for Four Sets of Loads with Reinforcing Plates.

area adds additional restraint to the column. Figure 16 illustrates a typical lug.

The effective width of the column would generally be controlled by the width of the base plate, multiplied by the cosine of the angle Θ. The vertical reaction Q, would then be resolved into two components, one causing column action in the lug, and the other tension and flexure along the hypothetical plane.

Such hypothetical distribution of forces are in line with similar convenient assumptions made by structural engineers, when dealing with continuous structures, such as slabs, and foundations.

Length L_1 is then tested and if found to be satisfactory structurally at reduced stressed due to temperatures from 100-200° less than vapor or liquid temperatures in the vessel, the design is assumed as satisfactory.

Flexural stresses are investigated along plane *a-a*, and will generally be found to be small.

"D" - Mean Diameter

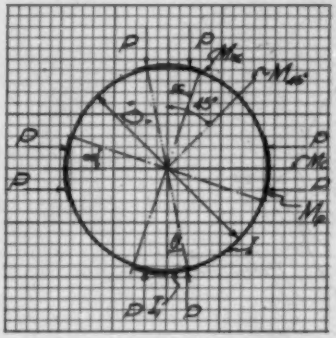
I_1 - M. of I. of Wall of Shell, Subtended by Angle "α"

I - M. of I. of Wall of Shell

M_D - Moment under Loads

M_α - Moment @ Angle "α"

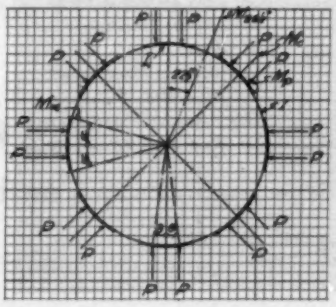
M_c - Moment @ ℄ of Loads



Another assumption frequently used, considers a series of planes such as *b-b*, *c-c*, and *d-d*. Moments shears and direct stresses are determined, and compared with certain reduced stresses established by judgment or from past experience.

Both methods will give different results. The first method will generally yield a heavier section, and therefore seems to be the preferred one.

It seems that column action is the more predominant part of the lug, as can be seen by making a paper model. By reproducing the action of the forces, it will be found that there is a more likely tendency to buckle, than to cause the lug to fail by any other manner. Since the lug is the most important member structurally, to close adherance to design stresses based on unverified assumptions does not appear to be a conservative approach to this problem.



Relationships of Lugs to Bottom of Head of Vessels

It is a common practice to locate lugs as close to the bottom head as possible, in order to shorten the effective height of the supporting structure.

At the junction of the head and the cylindrical portion of the vessel are developed, what is frequently called localized stresses.[6] These stresses are induced mutually by the head and cylinder in trying to reach a conformable position consistent with pressures, and elastic properties of materials. These stresses are flexural in nature longitudinally and circumferentially.

The longitudinal stresses in vessel are tensile on the inside, at the tangent line, and compressive on the outside. The longitudinal stresses due to internal pressure, will therefore be added to those from discontinuity stresses on the inside, and will decrease those on the outside of the shell.

The hoop stresses on the other hand are compressive at the tangent due to discontinuity conditions, and practically nullify those due to internal pressure.

Inasmuch as the premise on which the lug forces are carried is solely by ring action, it would seem that the position of the lug with respect to the tangent is not too important. The effect of lower lug forces would be to cancel somewhat those from discontinuity, and would present a more favorable stress situation in the lower part of the vessel.

In the upper portion of the lug, the effect of discontinuity stresses are practically zero. Hence the stresses from the lug action together with internal hoop stresses would have to be combined.

By the very nature of assumptions on which lug stresses are evaluated, stresses in the longitudinal direction are assumed not to resist hoop bending. Actually such stresses exist, but cannot be evaluated mathematically at present and would be additive to those from internal pressure.

The opinion shared by many engineers is that these stresses are not too critical, and are modified by plasticity of material. This is a convenient escape, based on performance of large

$$M_c = \frac{PD}{2}\left[\frac{I_1\{8\cos\alpha - 8(\sqrt{2}+1)\sin\alpha - (\pi - 8\alpha)\sin\theta - \pi(\sqrt{2}+1) + 8\alpha(\sqrt{2}+1)\} - 8I[(\cos\alpha - (\sqrt{2}+1)\sin\alpha - \cos\theta + (\alpha - \theta)\sin\theta + \alpha(\sqrt{2}+1)]}{8I\alpha + I_1(\pi - 8\alpha)}\right]$$

$$M_D = M_c + \frac{PD}{2}(\sqrt{2}+1)(1 - \cos\theta)$$

$$M_\alpha = M_c + \frac{PD}{2}\{(\sqrt{2}+1)(1 - \cos\theta) - \sin\alpha + \sin\theta\}$$

$$M_{22\frac{1}{2}^\circ} = M_c + \frac{PD}{2}\{(\sqrt{2}+1)(1 - \cos\theta) - \sin 22\tfrac{1}{2}^\circ + \sin\theta\}$$

Figure 13. Moments for Eight Sets of Loads with Reinforcing Plates.

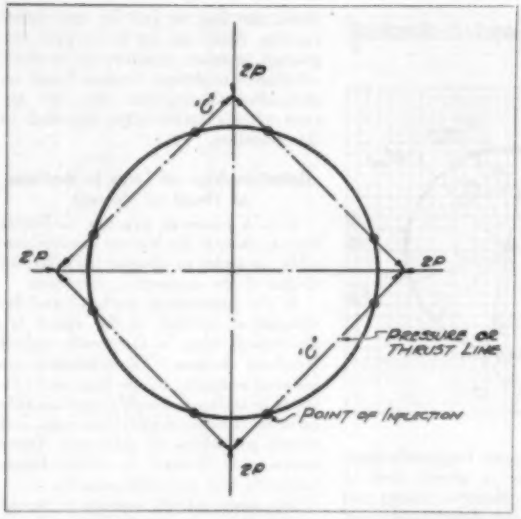
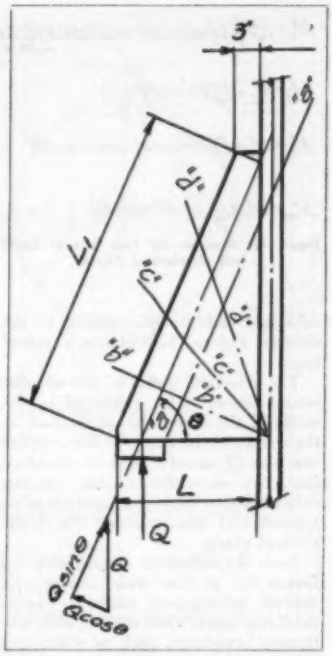


Figure 14

Figure 16



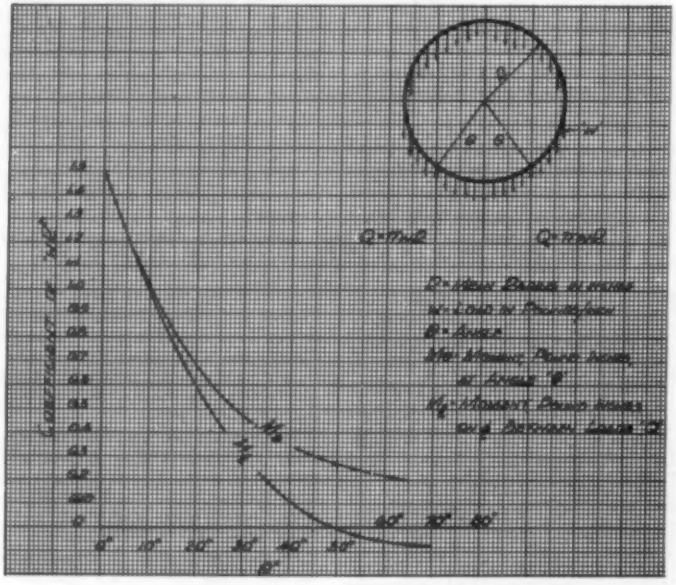


Figure 15. Influence Lines for Moments.

numbers of such structures.

The pressure stresses due to discontinuity are mathematically exact. Lug stresses however are based on assumed ring action, to the exclusion of resisting forces in the longitudinal direction, and therefore, approximate.

End of Part II. Part III will appear in an early issue.

NOTE

The auther, Mr. Wolosewick, is connected with Sargent and Lundy, Engineers, Chicago.

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* * *

Port Victoria, Isle of Grain, location of big Anglo-Iranian Refinery.

Good Progress Being Made On Isle of Grain Refinery

V. S. SWAMINATHAN, London

GOOD progress is being made by Anglo-Iranian Oil Company on its Kent refinery project in the Isle of Grain near London. Early in 1952 this plant will be processing about 42,000 barrels of crude oil daily. By the end of the same year the thruput capacity is to be doubled. A lube oil plant is scheduled to start operations in 1953, while in May of that year the catalytic cracker will come on stream.

Shortly after the last war an era of domestic refinery expansion was inaugurated in Britain. The capacity of two existing refineries of Anglo-Iranian in United Kingdom, one at Grangemouth in Scotland, and the other at Llandaray in Wales, has been greatly increased. These enlargements, however, were limited by market requirements in their respective zones, both being too far distant to supply the important London area economically.

Early in 1947 Anglo-Iranian Oil Company, Ltd., decided to erect a new refinery within a reasonable radius of London to meet demands in that zone. The site had to be one where deep sea tankers could berth close inshore to unload crude oil and load products. Finally chosen was the promontory formed by the confluence of the Thames and Medway estuaries in an area called the Isle of Grain—a little known corner of Kent.

It is on a part of mud flats which are now marshland that a considerable proportion of the refinery is being built. This task posed several complicated problems in the design of foundations, owing to the poor bearing value of the soil. These were overcome by special methods which included mass foundations, piling and rafting, the latter so termed because the structure is erected upon massive concrete "rafts."

Improvement of Access

Between the refinery and the nearest main centers of population, known as the "Medway Towns"—Chatham, Rochester and Strond—about 10 miles away, there are only small villages and hamlets connected by second-class country roads and a single line railway track which runs to a terminal point at Port Victoria, which is on the company's property. To improve general access to the refinery area a new by-pass road is

being built around the site, as well as a measure of straightening and widening of the narrow country roads in the locality and the replacement of weak road bridges.

Six hundred of the 2000 acres chosen for the refinery are due for immediate development. This work falls broadly into three distinct areas: The main crude oil processing section, a lubricating oil section—both of which lie to the south of the railway line traversing the site—and a main products tank farm with its jetties which lie to the south of the railway line. The administrative buildings, which are grouped about the refinery entrance, are approximately equidistant to these three areas.

The refinery is planned initially to process 2 million tons of crude oil per annum (about 42,000 barrels daily) with a lubricating oil production of about 2500 barrels daily—but it is so laid out that it could be readily expanded within a framework which would enable it to preserve a compact and workable entity at all stages of expansion. The crude unit has, however, a capacity considerably in excess of 2 million tons.

The main process units for the crude oil section of the refinery consist of one large crude distillation plant, two vacuum units and one catalytic cracker. The lube oil section will consist of a propane de-asphalting unit, a solvent extraction plant and de-waxing and clay treatment units. There will also be suitable facilities for blending, packaging and dispatching the lube oils either in bulk, or packages, by sea, rail or road. These facilities will be grouped near the terminus of the railway at Port Victoria and close to the loading jetty.

Additional plants for improving the quality of products are to be installed once the main process and lube oil units are in operation. They will include catalytic reformers for motor gasoline, a sulphur dioxide treatment plant for kerosine and a catalytic polymerization plant for light gases to enhance motor gasoline quality and quantity.

Four new deep sea tanker jetties are under construction in addition to a lube oil jetty. The existing distribution installation belonging to Medway Oil and Storage Company, which occupies the southwest corner of the site, will be absorbed into the scheme. Several large tanks are being erected to hold adequate stocks of crude oil and finished products, as well as numerous smaller tanks for the intermediate storage of products between the various processes.

Sea Water for Cooling

Sea water will be used throughout for cooling purposes, and an interesting feature will be a reservoir formed in a small bay on the river front to take advantage of the 19-foot rise and fall of the tide to trap sufficient water at high tide to keep the refinery running during low tide. Thus substantial pumping costs will be saved, though as the refinery cooling water requirements grow it will be necessary to install pumps to augment this supply. From the reservoir the sea water will be led to the edge of the refinery proper by a concrete-lined channel about three-fourths mile long, whence the main refinery circulating pumps will draw the supply for the cooling system. This cooling water will be discharged through oil-water separators near Port Victoria.

In the first stages electric power supplies will be obtained from the British Electricity Authority until such time as it is possible to complete a projected 16,000 k.v.a. power station inside the refinery. Thereafter, most of the power will come from that power station with a smaller offtake from the grid coupled with emergency links to take more power from the grid if necessary. Steam will be generated by boilers at 560 pounds pressure to drive the turbo-generators, and will exhaust at 250 and 180-pound pressure to supply process steam. On account of the unsuitability of local water supplies for boiler-feed purposes evaporators will be used for furnishing the boiler feed supply.

In addition to the administrative buildings, which include the main offices, laboratory, central canteen and bath house, time and wage offices, entrance, fire station and medical centre, the company is providing a small number of staff houses at Cirain Village, while the main housing requirements of the employes will be met by a building program to be undertaken by the local housing authority.

May, 1951 photo shows construction progress, Kent Refinery. Main road being built is shown in the foreground.

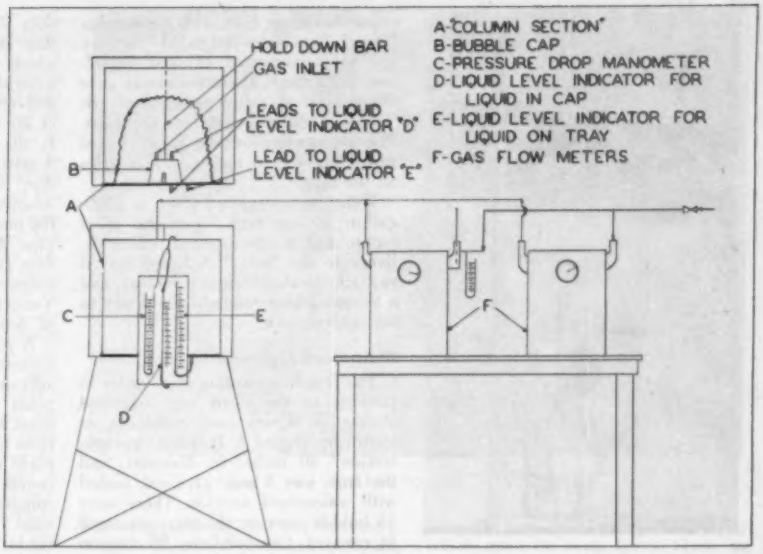

Figure 1. Apparatus for Pressure Drop Through Bubble Cap Slots.

Pressure Drop Through Bubble Caps

Part II. Equipment and Evaluation of Equations

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University of Oklahoma, Norman

Single Slot Apparatus

DURING the investigation there were several separate pieces of apparatus employed for different phases of the investigation. The first apparatus was assembled to study the variables on a single slot. A diagram of this apparatus is presented as Figure 1. Slots varying in width from 0.11 to 0.375 inch and in length from 0.333 to 1.25 inches were studied with this apparatus. The liquid seal was varied from 1.0 to 3.0 inches. The density of the liquid varied from 50 to 77 pounds per cubic foot. Gas densities varied from 0.058 to 0.113 pounds per cubic foot. The surface tension of the liquids varied from 34 to 72 dynes per centimeter.

THIS REPORT of the development of bubble tray pressure drop calculation methods is along the lines of basic theory and should be of much interest to designers. Part I appeared in the June issue and Part III will appear in an early PETROLEUM REFINER.

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Apparatus for Study of Surface Tension

The apparatus used to study the effect of surface tension on the pressure drop can be seen in Fig. 2. It consisted essentially of a 2 x 2 x 3-inch rectangular box with a slot in one side and two copper tubes. A draft gage and a 2000-milliliter beaker were the other essential pieces of equipment making up the apparatus. The slot was outlined by thin strips of copper gasket material which were thoroughly cleaned before each test.

The slot widths studied with this apparatus were 0.11 inch, 0.25 inch, and 0.375 inch. The surface tension of the water was lowered with aerosol to permit the investigation of the range of surface tension between 37 dynes per centimeter and 72 dynes per centimeter. In all studies, the seal depth, the length of the slot actually open, and the pressure on the manometer were recorded at the instant a bubble of air broke away from the submerged slot.

Glass Column Section Employing Two Caps

The third apparatus was set up to check the conclusion reached from the analysis of the experimental data on the single slot and the theoretical equations. A "column section" one-foot in diameter consisted of a wooden "tray," two bubble caps, liquid downcomer, glass tube for liquid overflow, and a glass shell. The bubble caps were two types as shown in Figure 3. The square type cap was a 4 x 4 x 3¼-inch cap with rectangular slots 3/16 x 1 inch. There were eight slots on one side; on three sides the slots were closed. Two of these caps were spaced 1½ inches

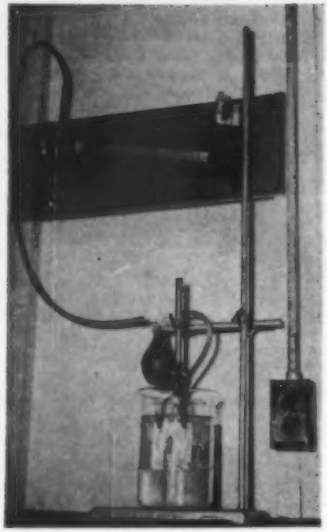


Figure 2. View of Apparatus Used for Study of Surface Tension Effect on Pressure Drop.

apart on the wooden tray with the open slots of each cap opposite those of the other cap and 90 degrees to the direction of flow of liquid across the tray. A 3/8-inch pipe nipple served as a gas inlet to each cap, and a 1/8-inch pipe nipple served as a lead to a manometer.

The other type of cap was a round cap with its inside diameter 3 7/8 inches. Its height was 2 3/4 inches including the legs which were 1/2 inch and spaced 120 degrees apart. There were 30 slots with a 3/16-inch width and a 1-inch height. A 3/8-inch pipe nipple in the center of the cap top served as a gas inlet, and a 1/8-inch pipe nipple served as a lead to a manometer. This type of cap was employed in two ways. The first was with a skirt clearance, and the second without the skirt clearance by cutting the legs off so the bottom of the slots rested on the tray. In each case two-thirds of the slots were closed, and the caps spaced 1 1/2 inches between edges with the open slots of one cap facing those of the other cap and at 90 degrees to the direction of flow of liquid on the tray.

The shell of the "column section" was a pyrex glass shell 1 foot in diameter and 2 1/2 feet in height. A false tray, consisting of a metal container, and a sheet metal downcomer sat on the wooden tray. The cross-sectional area of the downcomer was approximately ten percent of the plate area, and the area under the downspout was the same. The overflow for the liquid was a 2-inch glass tube. Four copper tubes were placed between the caps with the upper end being flush with the wooden "tray." They extended below the tray and were connected to four liquid-level indicators. These indicators gave the equivalent static pressure of the liquid on the tray between the caps. The manometer on the panel board was connected to the 1/8-inch nipples on the caps.

Water was supplied from a 1200-gallon storage tank by means of a pump, and it was metered before delivery to the "tray." A barrel served to catch the water leaving the tray, and a second pump returned the water to the storage tank.

Thirty-Inch Tray with 13 Caps

The fourth apparatus was similar in purpose to the third one described above, but it was more elaborate, as shown by Figure 4. It was a "column section" 30 inches in diameter, and the tray was 1-inch plywood coated with waterproof varnish. There were 13 bubble caps on the tray, arranged in rows of four-five-four, 90 degrees to the direction of flow of the liquid across the tray. The bubble caps were spaced at equidistances apart with 6 inches between centers. Four small pieces of sheet metal welded on the cap served to secure the caps to the tray by wood screws. The risers fitted tightly into the wooden tray and extended 2 inches above the tray. Ten percent of the tray was allotted to each, the liquid downcomer and the overflow. Forty lengths of copper tubing spaced at various points on the tray served as leads to liquid-level indicators on the panel board. They were flush with the tray and extended down through the section below the tray. The arrangement on the tray is shown in Figure 5.

The section below the tray was one foot in height and served as the false "tray" below, in that the air could be fed to this chamber with the only outlet being up the vapor risers. In this section were two taps; one was closed for a thermometer well, and the other was open for a manometer. An air duct 7 inches in diameter connected this chamber with an exhaust fan which was capable of working against a 5-inch static water head. A maximum delivery of 5000 cubic feet per minute of air could be obtained with this fan. In the air duct were two pitot tubes. A static manometer was also on the air duct. A "false tray" sat on the liquid downcomer to the tray. The water was fed into this "false tray" from a 2-inch pipe. A barrel served to catch the overflow from the tray. A second barrel connected to the first had a trough and V-notch weir which served as a means of determining the water flow rate.

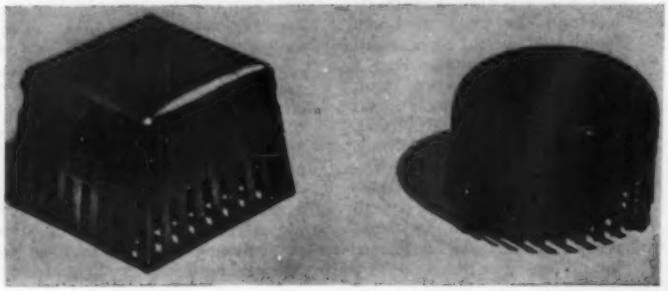
A panel board with ten liquid-level indicators was mounted on a metal adjustable stand. This allowed the panel board to be leveled and at the same height as the tray. The connections to the liquid-level indicators were made of rubber tubing and could be connected to any of the copper tubes coming from the tray. This arrangement facilitated the study of any particular portion on the tray with a minimum number of indicators on the panel board.

Evaluation of Theoretical Equations

Before Equation 19 could be of value, the constants placed in Equations 8 and 17 had to be evaluated, and a method of determining the value of L had to be established.

Preliminary tests were made with the apparatus employing the bubble cap with a single slot to determine whether or not the surface tension effect on the pressure drop could be neglected. It was noticed that the pressure differential through the slot varied for the same mass flow rate of air through different solutions of aerosol in water. Tests were made on one and two-inch seals with the surface tension being 37 and 72 dynes per centimeter. The difference in surface tension caused a difference in the pressure drops varying from 0.3 to 0.8 pounds per square foot with the lower differences being at the higher flow rates of the gas.

Figure 3. View of Square and Round Bubble Caps.



These results were in agreement with the theory as set forth when Equation 8 was derived.

At very low vapor rates, the length of the slot actually open to vapor flow depends upon the surface tension as well as the vapor rate. This is due to the fact that a minimum opening has to be obtained to lower the surface tension effect sufficiently to cause the bubbles of vapor to break away from the slot. At greater vapor rates, the slot becomes fully open, and the surface tension effect is lowered in three ways: 1) the length of the slot is greater; thus causing less pressure drop because the effect is inversely proportional to the radius of the bubble formed. 2) Once the slot is fully open, the vapor forces the liquid away from the slot, and the vapor does not come into contact with the liquid until it has left the slot. 3)[1] A surface active agent is present in most cases. A finite time is required to establish surface tension equilibrium in a solution containing a surface active agent. The higher rate of vapor flow makes it impossible to establish the equilibrium. This results in a higher apparent surface tension which approaches that of the pure liquid, and the pressure drop would approach that caused by the pure liquid.

Figure 6 shows the minimum slot opening for incipient flow as a function of surface tension. This minimum slot opening is the actual length of the slot which is open before a bubble can break away from the slot. Each bubble escapes through the slot separately. Water with aerosol served as the liquid, and air was the gas for which data were recorded. From this figure it is seen that the minimum slot opening is a function of both the width of the slot and of the surface tension. After the first bubble breaks away from the slot, subsequent bubbles break away from a somewhat smaller opening as long as they follow in rapid succession. This decrease in length of the active slot length is very small, and the original length is of more importance because it represents the length which must be open for a vapor to begin escaping from the slot. Since the pressure necessary to force the liquid level inside the cap below the top of the slot is dependent upon the extent to which the liquid has to be lowered before vapor can escape, this minimum length must be known in order to calculate the minimum pressure drop necessary for the cap to pass vapor.

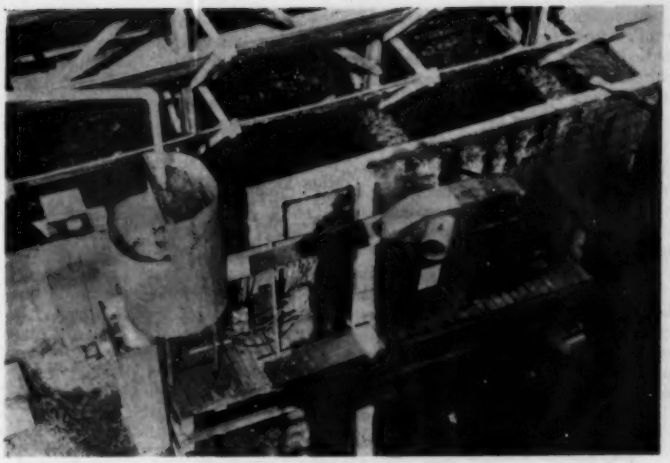


Figure 4. View of 30-Inch "Column Section" and Blower.

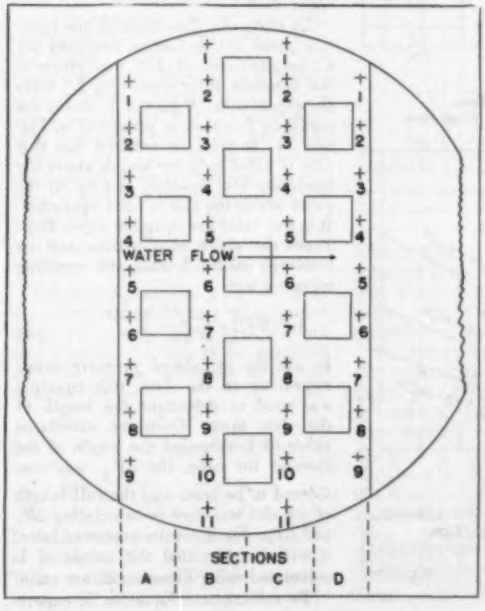


Figure 5. Diagram of 30-Inch Tray Showing Cap Arrangement and Points Where Equivalent Liquid Heights Were Obtained.

After the slot has been opened to the minimum for releasing a bubble of vapor, the surface tension has to be overcome. Of course, this minimum slot opening and surface tension cannot be separated, but for the sake of discussion, it is permissible to assume this minimum opening has been reached and the pressure now only makes the bubble break away from the slot. The pressure required is a function of the surface tension, length, and width of the slot as seen by Figure 7. These pressures were calculated from the height of liquid over the slot, the length of slot opening, and the pressure to cause a bubble to break through the slot. The static head to be overcome is the liquid head above the slot plus a liquid head equivalent to two-thirds the head offered by a static height of liquid having a height equal to the length of the opened portion of the slot. The sum of these heads was subtracted from the pressure indicated on the manometer at the moment the bubble broke away from the slot. The result was taken as the pressure necessary to overcome the resistance to vapor flow offered by the surface tension for that particular length and width of slot. These pressures were used in Equation 8 to evaluate the constant. Combining $\frac{2k}{g}$, there results

a new constant, K, which can be read from Figure 8 for the three slot widths studied. These K values can be used with accuracy of at least 90 percent in the equation,

$$\Delta P_\delta = \frac{K\delta(L+W)}{LW} \qquad (20)$$

The resulting ΔP_δ's are the maximum pressure drops due to surface tension. It is worthwhile to mention again that δ in this equation is expressed in pounds of force per foot.

The value of ΔP_δ is very small in a normally operating column, but if the vapor rate is low and the slots are operating only partially, the ΔP_δ pressure drop becomes larger than the pressure drop caused by the orifice effect. When the slot reaches full operating length, ΔP_δ is at a minimum. If the vapor rate is higher than the minimum necessary for a fully operating slot, Equation 20 does not apply, since the vapor does not contact the liquid until it leaves the slot. For this case ΔP_δ can be assumed to be zero.

To evaluate the constant in Equation 17, the single slot apparatus was used. A plot of $\frac{\rho_v Q^2}{2g L^2W^2}$ versus ΔP_o is presented in Figure 9. $\frac{Q_c^2}{A^2}$ is neglected since there was no riser in the cap. The ratio of cross sectional area of the cap to the slot area and the ratio of the area of the side of the cap to the slot area were 129:1 and 105:1 respectively. The slope of the line was taken as the value of C, and, when divided by the "2" in Equation 17, the result was

$$\Delta P_o = \frac{0.884\rho_v Q^2}{gL^2W^2} \qquad (21)$$

As stated previously in developing this equation, it was assumed the square of the average velocity was equal to the average of the velocities squared. This equation is only valid under those conditions when the vapor is flowing freely from the slot. It is believed the equation is valid since all slots of the caps were working. It is worthy to note that at the time this equation would become invalid, namely at very low flow rates for the vapor, the pressure drop due to the "orifice effect" of the slot is very small and could be neglected without serious error.

All the variables except the length of the slot operating are readily determined under actual operating conditions. Since the length of the slot operating is dependent on other variables, this equation cannot be used before the length of the slot in operation is known. Once the length is known, this equation can be used to calculate the pressure drop due to the vapor passing through the slot opening.

Before Equation 19 can be used, the length of the slot open must be known. It was found by direct observation that the length of the slot operating was a function of the pressure drop caused by the slot acting as an "orifice." This in turn caused the slot length operating to be a function of $\frac{\rho_v Q^2}{2g\rho_l L^2W^2}$.

To make the dimension of the function come out in feet as required for L, an exponent of 1/3 was given to the function after removing L^2 from the expression. A plot of L versus the resulting function is presented in Figure 10. It must be realized that this plot is valid only for length above the minimum slot opening and up to the point where the slot is fully operating. It is not valid for incipient vapor flow. From the slope of this line and its intercept on the L axis, the resulting equation was

$$L = 0.73\left[\frac{\rho_v Q^2}{W^2 g \rho_l}\right]^{0.257} \qquad (22)$$

In all the calculated pressure drops appearing in the data, this equation was used to determine the length of the slots open. Once the calculated value of L exceeded the length of the slots in the caps, the ΔP_δ was considered to be zero, and the full length of the slot was used in calculating ΔP_t and ΔP_o. From results presented later, it will be seen that the values of L calculated using Equation 22 are valid.

To substantiate Equation 5, experi-

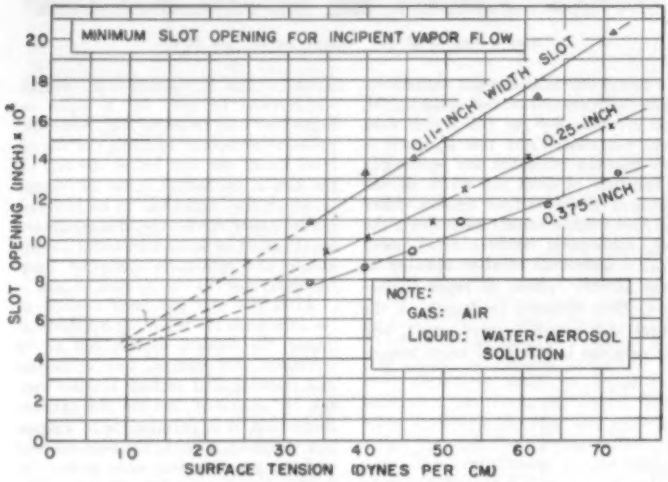
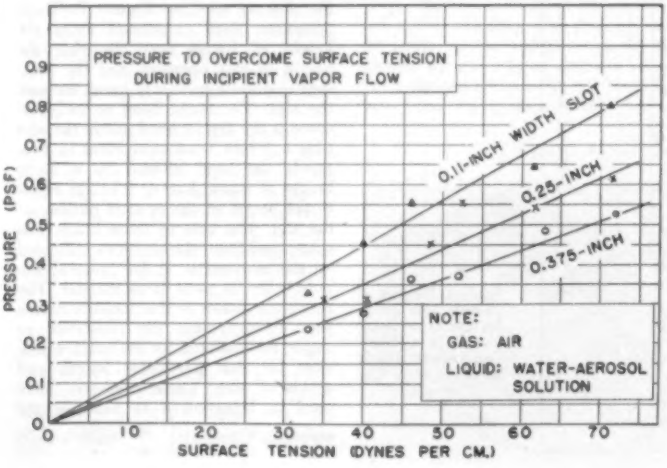


Figure 6 (above). Minimum Slot Opening for Incipient Vapor Flow.
Figure 7 (below). Pressure to Overcome Surface Tension During Incipient Vapor Flow.



mental data are presented graphically in Figure 11. $\Delta P - \Delta P_s$ represents the total pressure drop observed minus the liquid seal expressed in pounds per square foot. The value of V_s was calculated by dividing the flow rate in cubic feet per second by the total slot area in square feet. This gives a superficial slot velocity for the gas when the entire slot is not open. Once the slot has become fully opened, $(\Delta P - \Delta P_s)$ is a linear function of $\rho_v V_s^2$. If this linear function be extrapolated to $\rho_v V_s^2$ equal zero, there would result the pressure drop caused by the slot being fully open with no gas escaping through the slot. When this is done, the resulting values of $\Delta P - \Delta P_s$ are equal to approximately the pressure drops calculated by Equation 5. It seems worthwhile to mention that this extrapolated pressure drop would not include ΔP_δ since the extension was drawn from the linear function of $\rho_v V_s^2$ when the entire slot was open.

Figure 12 is a graphical presentation of the effect of the liquid viscosity on the pressure drop. In this test the viscosity was varied more than two-fold, and no difference in the pressure drop was noticed for the same mass flow of air through the slot. This result upholds the hypothesis set forth in deriving the equations. After vapor escapes through the slots, the viscosity of the liquid will govern in part the rate at which it rises to the surface, but this effect causes no pressure drop. It is thought this theory applies until very high vapor rates are reached except for the case of viscous liquids. If the liquid viscosity is extremely high, the viscous forces of the liquid will tend to make the liquid form a "bowl" around the slot, and the impact of the vapor against this "bowl" would result in a pressure increase on the inside of the bubble cap. At the viscosities encountered in most fractionating columns it is believed this effect would be negligible.

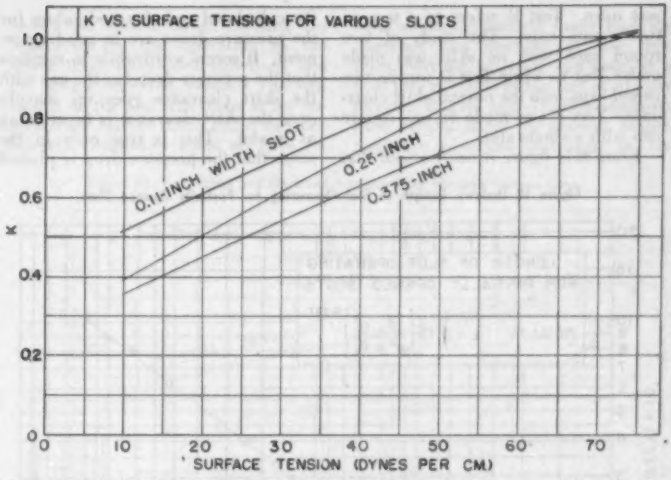
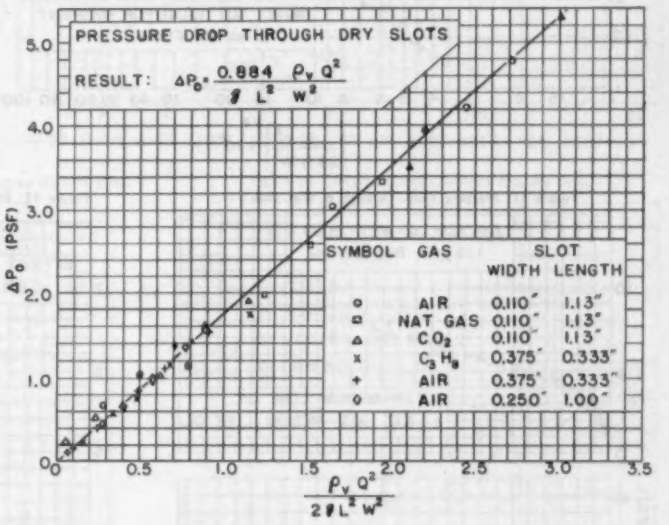


Figure 8 (above). K Values of Various Slots in Calculating Pressure to Overcome Surface Tension.
Figure 9 (below). Pressure Drop Through Dry Slots.



Calculated and Observed Pressure Drops

Before proceeding to a discussion of the calculated and observed pressure drops for various caps, it is thought that Equation 19 should be rewritten with the various constants set in the equation to give,

$$\Delta P = \frac{0.147\rho_v Q_c^2}{D^4} + \rho_l S + 2/3\rho_l L + \frac{K\delta(L+W)}{LW} + \frac{0.884\rho_v}{g}\left[\frac{Q^2}{L^2W^2} - \frac{Q_c^2}{A^2}\right] \quad (23)$$

It would only complicate the equation to substitute for L in Equation 23. Thus, in order to calculate the pressure drop, two equations will be used; namely Equation 22 to determine the value of L and Equation 23 to calculate the pressure drop knowing the value of L. Values of K may be obtained from Figure 8.

The term ρ_l refers to the density of the liquid above the slots while the cap is in operation. This means that in most cases the density will be less than expected because of the aeration effect. A search of the literature reveals that the best reported values for this type of aeration are those of Kemp and Pyle.[4] The values range down from 1.0 and must be multiplied by the density of the liquid under static conditions to obtain a value for ρ_l in Equation 23. Actual aeration factors were determined when data were collected on the one-foot tray but not on the 30-inch tray. On the 30-inch tray the equivalent height of the seal was determined and no aeration factor was necessary for the ρ_l in the $\rho_l S$ term, but it was necessary to use Kemp and Pyle's[4] values for the aeration factor in calculating the term, $2/3\rho_l L$.

Figure 13 is a plot of the actual and observed pressure drops for various flow conditions of air and water on different caps employed on the one-foot tray. The air flow rate is expressed as the pounds of vapor per second per square foot of slot area actually operating. All slot openings were calculated by Equation 22 until the entire slot

was open. Test B refers to a test on two square caps. The study of two round caps with no skirt was made under Test C, while Test D was on two round caps with the normal skirt clearance. Test E was made on one square cap with a single slot.

From this figure it can be seen that the calculated and observed values for the pressure drops are in good agreement. It seems worthwhile to mention that the pressure drop for the cap with the skirt clearance goes up sharply once the skirt clearance is functioning as a slot. This is true only in the sense that the pressure drop is plotted versus the pounds of vapor per second per square foot of slot area actually operating. Once the skirt clearance starts operating, the slot area is increased greatly, thus causing the mass flow rate to increase more slowly than if only the slots were operating.

Pressure drop data for the 30-inch tray are presented in Figure 14. As mentioned previously, the equivalent height of liquid on the tray was read from the liquid level on the panel board at different points on the tray. The tops of the slots were 1.15 inches above the tray. The equivalent liquid seal was the difference between the panel board reading and the height of the slots above the tray. Actually, the water level on the tray was higher than indicated by the readings on the panel board due to the aeration effect, but the static head above the slots was less than the actual height of the aerated water and equal to the equivalent liquid seal. The aeration effect for that part of the static head on the same plane as the opened portion of the slots was not known. Kemp and Pyle's[4] aeration factors were used and from their data a factor of 0.80 was used in calculating this pressure drop.

The water flow rate in Figure 14 is plotted as gpm per foot of tray width. The tray was 30 inches wide at the

Figure 10 (below). Length of Slot Operating for Partially Opened Slots.

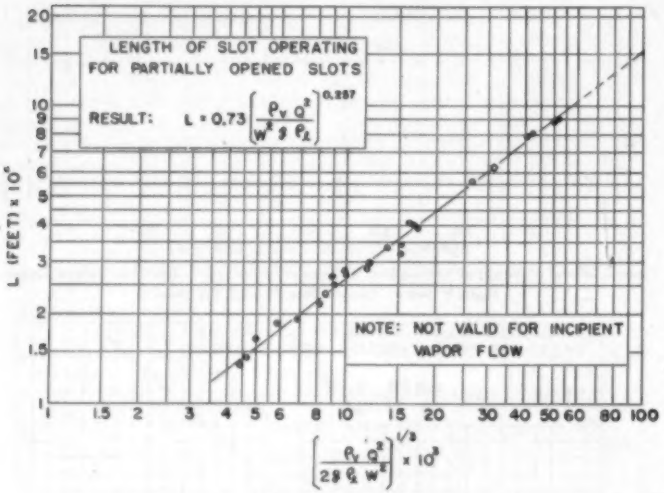

LENGTH OF SLOT OPERATING
FOR PARTIALLY OPENED SLOTS
RESULT: $L = 0.73 \left(\frac{\rho_v Q^2}{W^2 g \rho_L} \right)^{0.257}$
NOTE: NOT VALID FOR INCIPIENT VAPOR FLOW
L (FEET) x 10⁶
$\left(\frac{\rho_v Q^2}{2 g \rho_L W^2} \right)^{1/3} \times 10^3$

Figure 11. Pressure Drop Through a Wet Slot.

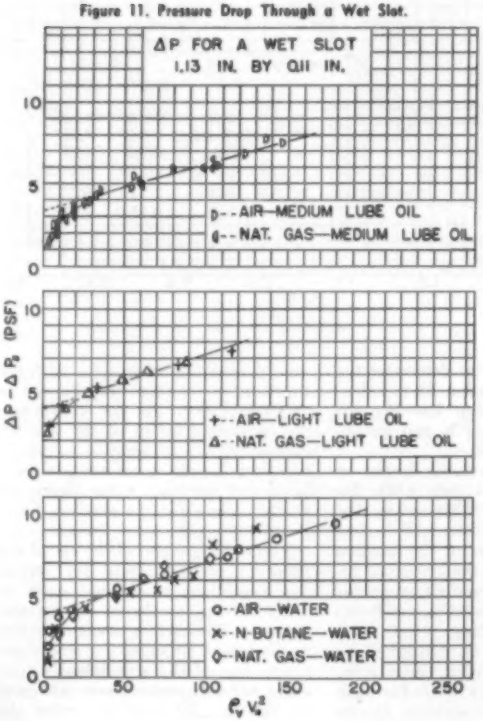
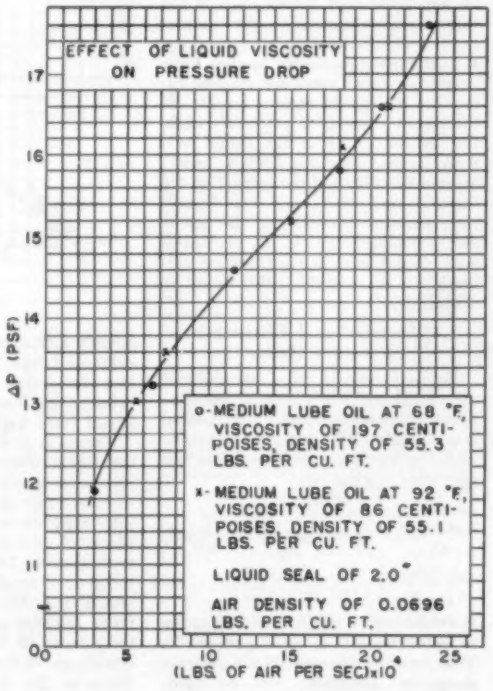


Figure 12. Effect of Liquid Viscosity on Pressure Drop.


EFFECT OF LIQUID VISCOSITY
ON PRESSURE DROP
o-MEDIUM LUBE OIL AT 68 °F, VISCOSITY OF 197 CENTIPOISES, DENSITY OF 55.3 LBS. PER CU. FT.
x-MEDIUM LUBE OIL AT 92 °F, VISCOSITY OF 86 CENTIPOISES, DENSITY OF 55.1 LBS. PER CU. FT.
LIQUID SEAL OF 2.0"
AIR DENSITY OF 0.0696 LBS. PER CU. FT.
ΔP (PSF)
(LBS. OF AIR PER SEC) x 10⁴

middle row of caps and 24 inches wide at the entrance to the first row of caps and exit of the last row of caps. Again Equations 22 and 23 were used to obtain the calculated pressure drops. The observed readings were taken from a static manometer located below the tray.

Equation 22, for the length of the slot actually operating, was compared with equations offered by Griswold[3] and Rogers and Thiele.[6] Griswold gives

$$h = 1.81 V^{2/3} \left[\frac{\rho_v}{\rho_l} \right]^{1/3} \quad (24)$$

where h = slot opening in inches for rectangular slots
V = gas rate in cu. ft. per min. per inch of slot width
ρ_v = density of the gas
ρ_l = density of the liquid

Rogers and Thiele give

$$V = (0.51)(0.078)h^{1/2} \quad (25)$$

where V = volume of air through one slot in cu. ft. per sec.
h = slot length in inches

Sherwood[3] states these equations are useful in obtaining approximate values of the slot opening.

A test was made on a 1/4 x 1-inch slot using air and water. Figure 15 shows the results of calculating the length of the slot operating by the above three mentioned equations and the actual observed values. The full length of the slot was open at an observed air rate of 0.058 cubic feet per second. Griswold's equation gave results about ten percent lower than the observed slot opening at low flow rates, and the full slot was open at a flow rate of 0.055 cubic feet of air per second. Rogers and Thiele's equation gave results about 10 percent higher than the observed openings at the

Figure 13. Calculated and Observed Pressure Drop Through Various Caps.

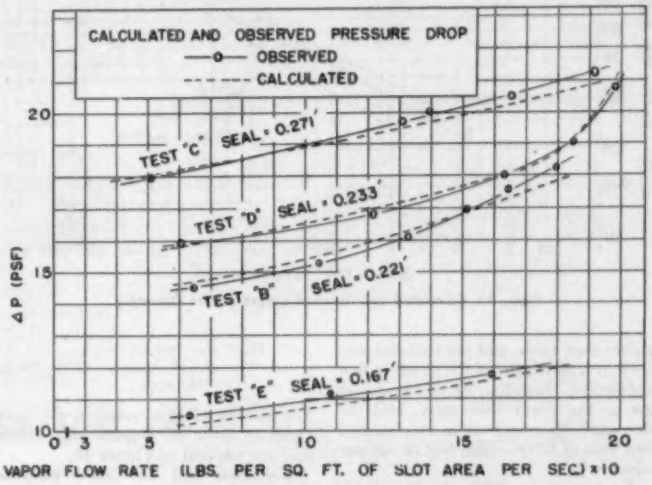

CALCULATED AND OBSERVED PRESSURE DROP
OBSERVED
CALCULATED
TEST "C" SEAL = 0.271"
TEST "D" SEAL = 0.233"
TEST "B" SEAL = 0.221"
TEST "E" SEAL = 0.167"
ΔP (PSF)
VAPOR FLOW RATE (LBS. PER SQ. FT. OF SLOT AREA PER SEC.) x 10

Figure 14. Calculated and Observed Pressure Drop on 30-Inch Tray.

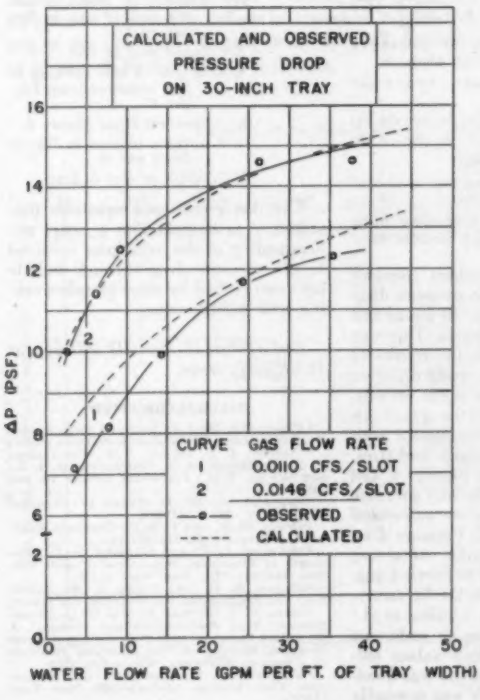
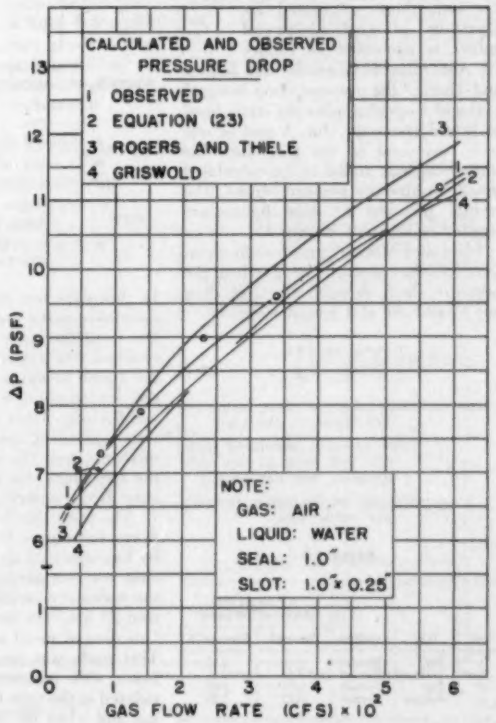


Figure 16. Calculated and Observed Pressure Drop.



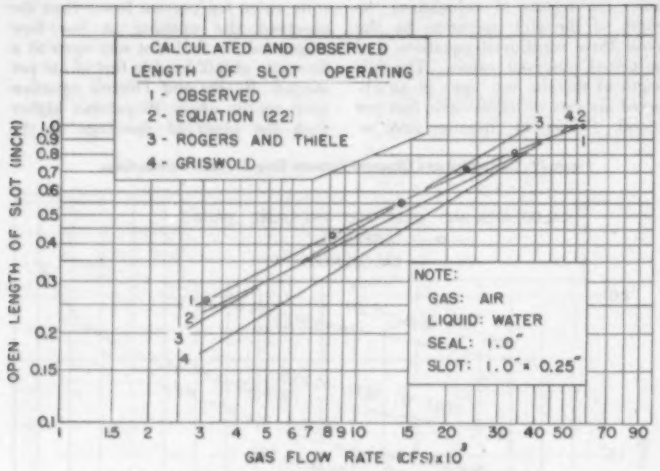


Figure 15. Calculated and Observed Length of Slot Operating.

higher flow rates, and the full slot was open at a flow rate of 0.038 cubic feet per second. Equation 22 was 4 percent low at the lower flow rates, and the slot was fully operating at a calculated flow rate of 0.056 cubic feet of air per second.

A comparison of the pressure drops calculated by Equations 24 and 25 with those calculated by Equation 23 and observed values is presented as Figure 16. According to Griswold[3] and Rogers and Thiele,[6] the pressure drop is equal to the slot opening plus the static head of liquid above the slot. A seal of one inch was used in the test, and this static head was added to the calculated length to give the pressure drops. The results pictured by this figure are similar to those of Figure 15.

Rhys and Minich[7] propose an equation for the pressure drop when the pressure drop through the slot does not exceed the slot length which is

$$h_s = 0.29\left[\frac{V^2 \rho_v H_s}{S}\right]^{1/3} \qquad (26)$$

where h_s = slot pressure drop, inches of hot liquid on the tray

V = slot velocity calculated with the full area of the slot opening, feet per second

ρ_v = density of the vapor, pounds per cubic foot

H_s = slot height, inches

S = specific gravity of liquid on the tray

The results of this equation are very close to those of Rogers and Thiele and are omitted in Figure 16.

Robinson and Gilliland[5] propose the equation

$$h_s = 0.12\frac{\alpha}{\rho_l} + K\left[h_s^{0.5} V_s \sqrt{\frac{\rho_v}{\rho_l - \rho_v}}\right]^{0.67} \qquad (27)$$

where h_s = slot opening or pressure drop through slots, in.

α = surface tension, dynes per cm.

ρ_l = liquid density, lb. per cu. ft.

ρ_v = vapor density, lb. per cu. ft.

$h_s^{0.5}$ = slot height, in.

V_s = velocity based on total slot area, f. p. s.

K = a constant depending upon cap and slot dimensions.

In this equation the authors consider the slot opening and the pressure drop due to surface tension to be equal and constant for a given liquid. This was not found to agree with the results of this investigation when using different width slots. Tests were made on oils, water, glycerin, and water-glycerin mixtures, and the results agreed with the minimum slot openings and pressure drops reported in Figures 6 and 7. The open slot lengths and pressure drops were lower than those calculated by Equations 22 and 23. Pressure drop data on commercial units containing the necessary variables to check Equation 23 are very rare in the literature. One case of merit is by Cicalese et al.[2] This study was made on an isobutane tower with pressure drop values calculated at the time the tower was flooding and when the tower was normally operating. Table 1 is a summary:

TABLE 1

Test	Tray	Condition	ΔP Across Tray (Inches of Hot Liquid) Reported	Equation 23
1	Top	Flooded	4.01	4.12
1	Bottom	Flooded	4.56	4.61
2	Top	Normal	4.73	4.60
2	Bottom	Normal	5.22	5.30

Surface tension was not taken into account by previous investigators[2,3,6] in calculating the length of the slot. No attention was given to the minimum slot opening for the vapor to pass through the slots. Rogers and Thiele's[6] comparison of their experimental and calculated results does show the calculated results are low at very low flow rates and mention that the surface tension affects this minimum opening. As stated previously, the effect of surface tension is most important at the minimum flow, and this is thought to be the reason why their calculated results are low. This effect is also important in determining the minimum pressure drop for a cap. Rhys and Minich[7] state that the use of caps with a relatively high pressure drop insures good distribution of vapor on the tray. Thus it becomes important to determine the minimum pressure drop necessary for a cap to pass vapor. The minimum pressure drop can be determined by applying Equation 23 to incipient vapor flow, from which would result

$$\Delta P_m = \rho_l S + 2/3\rho_l L + \frac{K\delta(L+W)}{LW} \qquad (28)$$

where ΔP_m = minimum pressure drop through the bubble cap in lbs. per sq. ft.

ρ_l = density of liquid above the bubble cap in lbs. per cu. ft.

S = liquid seal in feet

L = length of slot opening in feet obtained from Figure 6

K = constant from Figure 8

δ = surface tension in lbs. of force per ft.

W = width of slot in feet

With the results and equations presented, it is thought that a better understanding of the principles involved in the pressure drop through bubble caps can be had by those people working with bubble caps.

End of Part II. Part III will appear in an early issue.

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THERMOCHEMISTRY for the Petrochemical Industry

Part XVII—Some C_3 Oxygenated Hydrocarbons

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THE THERMODYNAMIC properties of the following groups of compounds have been presented in previous papers of this series: paraffinic hydrocarbons,[11] mono-olefinic hydrocarbons,[12] cycloparaffinic hydrocarbons,[13] aromatic hydrocarbons,[14] acetylenic and diolefinic hydrocarbons,[15] combustion gases,[16] sulfur compounds,[17] halogens and halogen acids,[18] chloromethanes,[19] cyanogen compounds,[20] the oxides of nitrogen,[21] some oxygenated hydrocarbons—C_1 and C_2,[22] and some miscellaneous hydrocarbons.[23] This paper now presents the data for some C_3 oxygenated hydrocarbons—carbon suboxide, acetone, iso-propyl alcohol, n-propyl alcohol, and allyl alcohol.

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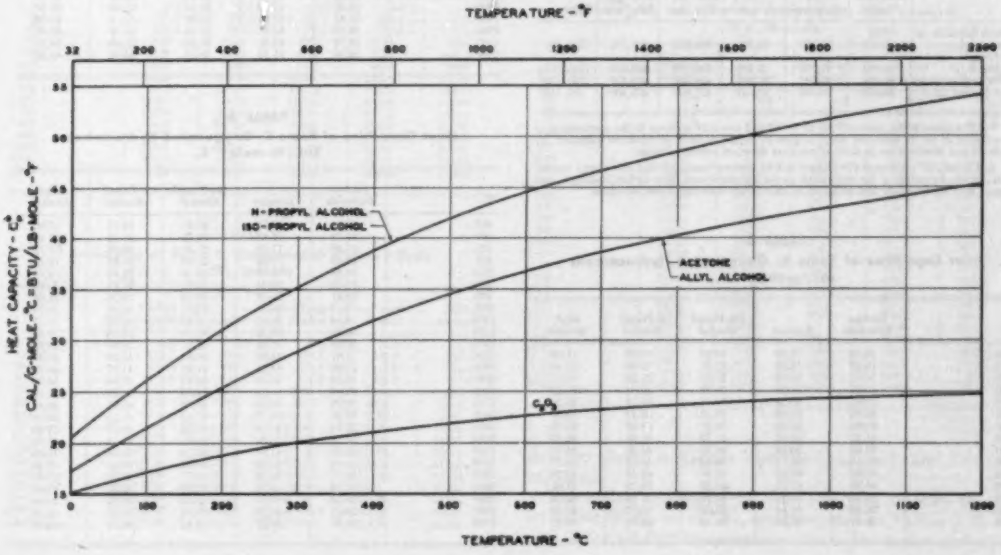
THIS paper extends those data previously presented on some C_1 and C_2 oxygenated hydrocarbons.[22] In particular it deals with the C_3 alcohols, n-propyl, iso-propyl, and allyl alcohols, the industrial importance of which has increased each year. Acetone may be produced by the dehydration of isopropyl alcohol, so that the petrochemical industry is particularly interested in this reaction and the properties of the product. Carbon suboxide is a little known oxide of carbon, but is an inner anhydride like ketene and like it, may become of importance as an acid anhydride if it can be produced cheaply.

Table I summarizes the heat capacity determinations of carbon suboxide, acetone, iso-propyl alcohol, n-propyl alcohol, and allyl alcohol. The temperature range, method of derivation of the data and references are given in each case. It is noted that few data have been reported for this group of compounds.

The only data available in the literature for carbon suboxide are those of Thompson.[27] The data were recalculated using his frequency assignments and newer improved values of the physical constants. The range of temperatures was extended also.

With the exception of a few scattered points, the only data available for acetone are those of Godnev, Pajuchina, and Swerdlin.[6] These data were smoothed by means of difference plots.

Figure 1. Molar Heat Capacities of Ideal Gases on Centigrade and Fahrenheit Scales.



Heat capacity data for iso-propyl alcohol have been reported at only a few scattered points. Accordingly, the data presented here were calculated from spectroscopic data. The necessary data and method were taken from the article by Aston, Isserow, Szasz, and Kennedy.[1]

Since data at only a few points were available for n-propyl alcohol and allyl alcohol, the data presented here were calculated from spectroscopic data. Frequency assignments were made and barrier heights to internal rotation were chosen. The method of calculation was that given by Kilpatrick and Pitzer.[9]

The free energies and heats of formation and heats of combustion are given in Table 2. These values were calculated from the indicated references.

The molar heat capacities of the ideal gases on all temperature scales are given in Tables 3, 4, 5, and 6. These

TABLE 1

Reported Heat Capacity Data for Some C_3 Oxygenated Hydrocarbons

Compound	Temperature Range	Method	Workers	Reference
Carbon Suboxide	279.26—1000 °K.	Spectroscopic	Thompson	(27)
Acetone	88—181 °C.	Spectroscopic	Dobratz	(4)
	137 °C.	Spectroscopic	Bennewitz and Rosner	(3)
	60—181 °C.	Velocity of Sound	Jatkar	(7)
	61—166 °C.	Calorimetric	Collins, Coleman and De Vries	(3)
	298.16—1500 °K.	Spectroscopic	Godnev, Pajuchina and Swerdlin	(6)
Iso-Propyl Alcohol	97.1 °C. and 134 °C.	Velocity of Sound	Jatkar	(7)
	134 °C.	Velocity of Sound	Jatkar and Lakshminarayanan	(8)
	410 °K.	Calorimetric	Bennewitz and Rosner	(2)
	427.9, 457.7 and 480.3 °K.	Calorimetric	Parks and Shomate	(26)
	427.9, 457.7 and 480.2 °K.	Spectroscopic	Aston, Isserow, Szasz, and Kennedy	(1)
	273.16—1500 °K.	Spectroscopic	Kobe, Harrison, and Pennington	(10)
n-Propyl Alcohol	97.1 °C. and 134 °C.	Velocity of Sound	Jatkar	(7)
	134 °C.	Velocity of Sound	Jatkar and Lakshminarayanan	(8)
	410 °K.	Calorimetric	Bennewitz and Rosner	(2)
	273.16—1500 °K.	Spectroscopic	Kobe, Harrison, and Pennington	(10)
Allyl Alcohol	273.16—1500 °K.	Spectroscopic	Kobe, Harrison, and Pennington	(10)

TABLE 2

Free Energies of Formation, Heats of Formation, Heats of Combustion, and Molecular Weights of Some C_3 Oxygenated Hydrocarbons, at 25 °C.[1]

	Molecular Weight	$-\Delta G°_f$, cal./g-mole	$-\Delta H°_f$, cal./g-mole	$-\Delta H°$, cal./g-mole H_2O (liq.) CO_2 (gas)	H_2O (gas) CO_2 (gas)	Reference
Carbon Suboxide (g)	68.03	.....	.....	.....	.....	.....
Acetone (g)	58.078	36,420	51,700	435,220	403,770	(24), (6)
Iso-Propyl Alcohol (g)	60.094	41,700	65,400	490,000	448,000	(26), (10)
n-Propyl Alcohol (g)	60.094	38,040	61,000	494,400	452,400	(25), (10)
Allyl Alcohol (g)	58.078	15,220	29,730	457,400	425,800	(5), (10)

[1] $-\Delta H$ represents the heat evolved at 25 °C. and constant pressure in the combustion of the compounds (in the indicated state) in gaseous oxygen to form the products indicated. All reactants and products are in their appropriate standard reference states.

$\Delta H°_f$ and $\Delta G°_f$ represent the changes in heat content (enthalpy) and free energy respectively, for the formation of the compounds in the indicated state from carbon, hydrogen, and oxygen, with all reactants and products in appropriate standard reference states.

TABLE 3

Heat Capacities of Some C_3 Oxygenated Hydrocarbons cal./g-mole · °C.

°C.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
0	15.05	17.20	20.50	19.78	17.00
18	15.52	18.02	21.51	20.90	17.84
20	15.69	18.38	21.90	21.33	18.17
100	17.25	21.59	26.08	25.91	21.63
200	18.91	25.33	31.11	31.16	25.79
300	20.04	29.02	35.20	35.61	29.28
400	21.04	32.06	38.81	38.89	32.20
500	21.87	34.65	41.78	41.84	34.68
600	22.56	36.84	44.35	44.36	36.82
700	23.14	38.71	46.50	46.55	38.63
800	23.62	40.32	48.34	48.48	40.20
900	24.02	41.75	50.20	50.10	41.51
1000	24.36	43.01	51.70	51.64	42.64
1100	24.64	44.14	53.03	52.87	43.89
1200	24.89	45.20	54.13	53.99	44.82

TABLE 4

Heat Capacities of Some C_3 Oxygenated Hydrocarbons cal./g-mole · °K.

°K.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
273.16	15.05	17.20	20.50	19.78	17.00
291.16	15.52	18.02	21.51	20.90	17.84
293.16	15.69	18.38	21.90	21.33	18.17
300	15.73	18.42	22.00	21.47	18.25
400	17.72	22.09	27.50	27.42	22.81
500	19.17	26.51	32.31	32.40	26.79
600	20.33	29.88	36.39	36.40	30.11
700	21.29	32.80	39.66	39.73	32.91
800	22.07	35.27	42.50	42.56	35.28
900	22.73	37.37	44.99	44.97	37.35
1000	23.29	39.17	47.14	47.10	39.06
1100	23.74	40.73	49.02	48.96	40.60
1200	24.12	42.10	50.60	50.61	41.96
1300	24.44	43.33	52.09	51.96	43.14
1400	24.71	44.43	53.34	53.18	44.15
1500	24.94	45.47	54.43	54.28	45.06

TABLE 5

Heat Capacities of Some C_3 Oxygenated Hydrocarbons Btu./lb-mole · °F.

°F.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
32	15.05	17.20	20.50	19.78	17.00
60	15.46	17.80	21.33	20.75	17.73
77	15.69	18.38	21.90	21.33	18.17
100	15.98	18.88	22.62	22.16	18.77
200	17.13	21.32	25.71	25.52	21.33
300	18.07	23.58	28.63	28.61	23.74
400	18.86	25.70	31.31	31.37	25.96
500	19.58	27.66	33.72	33.83	27.96
600	20.21	29.53	35.86	35.99	29.77
700	20.77	31.33	37.85	37.94	31.41
800	21.28	32.90	39.65	39.72	32.91
900	21.73	34.22	41.29	41.38	34.27
1000	22.15	35.53	42.79	42.84	35.53
1100	22.53	36.70	44.19	44.20	36.69
1200	22.86	37.79	45.49	45.40	37.76
1300	23.17	38.76	46.69	46.66	38.73
1400	23.44	39.71	47.80	47.74	39.56
1500	23.69	40.57	48.82	48.75	40.43
1600	23.92	41.36	49.75	49.71	41.22
1700	24.12	42.10	50.60	50.61	41.96
1800	24.30	42.79	51.44	51.40	42.64
1900	24.47	43.44	52.24	52.12	43.26
2000	24.62	44.07	52.96	52.79	43.83
2100	24.76	44.66	53.59	53.43	44.38
2200	24.89	45.24	54.18	54.04	44.86

TABLE 6

Heat Capacities of Some C_3 Oxygenated Hydrocarbons Btu./lb-mole · °R.

°R	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
492	15.05	17.20	20.50	19.78	17.00
500	15.18	17.41	20.75	20.05	17.19
520	15.46	17.89	21.34	20.75	17.73
537	15.69	18.38	21.90	21.33	18.17
600	16.48	19.89	23.88	23.54	19.82
700	17.53	22.24	26.91	26.81	22.32
800	18.41	24.44	29.74	29.76	24.66
900	19.17	26.51	32.31	32.40	26.79
1000	19.84	28.44	34.62	34.73	28.71
1100	20.44	30.22	36.69	36.80	30.45
1200	20.96	31.88	38.57	38.66	32.03
1300	21.47	33.39	40.33	40.39	33.47
1400	21.90	34.75	41.91	41.97	34.79
1500	22.30	36.00	43.37	43.40	36.00
1600	22.66	37.13	44.73	44.72	37.13
1700	22.99	38.20	45.98	45.96	38.16
1800	23.28	39.17	47.15	47.10	39.08
1900	23.54	40.08	48.25	48.16	39.93
2000	23.79	40.89	49.21	49.14	40.75
2100	24.00	41.66	50.10	50.08	41.52
2200	24.19	42.38	50.94	50.94	42.24
2300	24.37	43.06	51.77	51.70	42.90
2400	24.53	43.70	52.54	52.39	43.50
2500	24.68	44.31	53.29	53.05	44.04
2600	24.81	44.90	53.63	53.66	44.55
2700	24.94	45.47	54.42	54.28	45.06

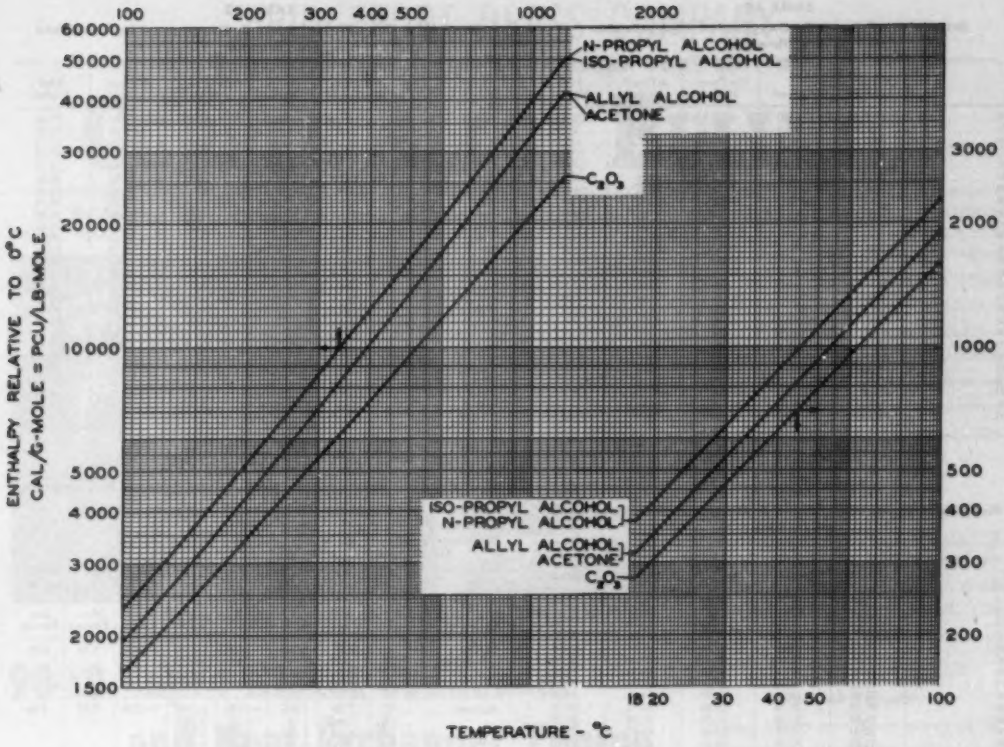


Figure 2. (above) Relative Enthalpies of Carbon Suboxide, Acetone, Iso-Propyl Alcohol, N-Propyl Alcohol and Allyl Alcohol.

TABLE 7
Enthalpies of Some C_3 Oxygenated Hydrocarbons
cal./g-mole

°C.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
0	0.0	0.0	0.0	0.0	0.0
15	275.3	316.9	379.2	366.1	313.4
25	384.5	444.3	530.5	513.9	439.4
100	1633	1943	2252	2268	1933
200	3420	4308	5197	5153	4310
300	5374	7034	8535	8489	7089
400	7420	10090	12240	12210	10150
500	9576	13430	16270	16250	13490
600	11800	17010	20580	20560	17070
700	14090	20790	25130	25110	20850
800	16420	24740	29990	29980	24790
900	18810	28850	34820	34800	28880
1000	21230	33090	39910	39900	33100
1100	23680	37450	45160	45120	37450
1200	26150	41910	50530	50490	41890

TABLE 8
Enthalpies of Some C_3 Oxygenated Hydrocarbons
cal./g-mole

°K.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
273.16	0.0	0.0	0.0	0.0	0.0
291.16	275.2	316.9	379.3	366.1	313.4
298.16	384.5	444.3	530.6	513.9	439.4
300	413.4	481.1	571.5	553.2	472.9
400	2092	2544	3053	3006	2530
500	3939	4998	6051	6006	5016
600	5916	7826	9497	9453	7866
700	7998	10960	13290	13260	11020
800	10179	14370	17400	17380	14430
900	12410	18000	21770	21760	18070
1000	14710	21820	26380	26370	21890
1100	17060	25830	31200	31170	25870
1200	19450	29990	36170	36150	30000
1300	21880	34240	41310	41290	34260
1400	24340	38630	46590	46540	38630
1500	26820	43110	51990	51920	43090

TABLE 9
Enthalpies of Some C_3 Oxygenated Hydrocarbons
Btu./lb-mole

°F.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
32	0.0	0.0	0.0	0.0	0.0
60	437.3	491.5	590.4	567.4	486.0
77	692.0	799.8	955.3	925.0	790.0
100	1057	1228	1470	1424	1215
200	2715	3370	3887	3810	3231
300	4476	5512	6612	6519	5474
400	6325	7974	9610	9520	7981
500	8248	10640	12670	12780	10660
600	10240	13500	16360	16280	13550
700	12290	16540	20050	19970	16610
800	14390	19720	23920	23860	19820
900	16540	23090	27960	27910	23180
1000	18740	26570	32170	32120	26670
1100	20970	30180	36510	36450	30290
1200	23240	33900	40980	40950	34010
1300	25540	37730	45590	45570	37830
1400	27870	41650	50330	50290	41750
1500	30220	45660	55170	55110	45750
1600	32610	49760	60100	60030	49830
1700	35010	53930	65110	65050	53990
1800	37430	58180	70210	70150	58220
1900	39860	62490	75410	75320	62520
2000	42320	66860	80680	80580	66880
2100	44780	71300	85990	85890	71280
2200	47270	75800	91300	91280	75740

data are shown in Figure 1 on the Centigrade and Fahrenheit scales.

The molar enthalpies of the ideal gas, relative to the ice point, 0° C. = 32° F., are presented in Tables 7, 8, 9, and 10 for all four temperature scales. The molar enthalpy

TABLE 10

Enthalpies of Some C_1 Oxygenated Hydrocarbons
Btu./lb.-mole

°R.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
492	0.0	0.0	0.0	0.0	0.0
500	125.7	138.5	167.8	184.1	142.2
520	427.3	491.5	590.4	567.4	486.0
537	692.0	799.8	955.2	925.0	790.9
600	1712	2006	2397	2345	1993
700	3414	4113	4951	4864	4100
800	5212	6447	7781	7695	6449
900	7062	8953	10890	10880	9024
1000	9043	11740	14240	14160	11800
1100	11060	14670	17830	17750	14760
1200	13130	17780	21580	21510	17890
1300	15270	21040	25520	25470	21160
1400	17540	24440	29630	29590	24570
1500	19750	27980	33980	33950	28110
1600	22000	31640	38280	38270	31780
1700	24280	35410	42810	42800	35540
1800	26600	39270	48020	47460	39400
1900	28940	43240	52250	52220	43350
2000	31300	47280	57130	57090	47380
2100	33690	51410	62080	62040	51500
2200	36100	55610	67140	67100	55690
2300	38530	59890	72290	72230	59940
2400	40980	64220	77520	77440	64270
2500	43440	68620	82800	82710	68650
2600	45910	73080	88140	88050	73070
2700	48280	77600	93580	93460	77560

TABLE 11

Mean Heat Capacities of Some C_1 Oxygenated Hydrocarbons
cal./g-mole • °C.

°C.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
0	15.05	17.20	20.50	19.78	17.00
18	15.29	17.61	21.07	20.34	17.41
25	15.38	17.77	21.22	20.56	17.58
100	16.23	19.66	23.32	22.88	19.33
200	17.15	21.60	25.99	25.76	21.55
300	17.91	23.52	28.45	28.30	23.56
400	18.57	25.24	30.60	30.53	25.38
500	19.15	26.86	32.54	32.50	26.98
600	19.65	28.35	34.29	34.27	28.45
700	20.12	28.70	35.89	35.87	29.79
800	20.53	30.93	37.36	37.32	30.99
900	20.90	32.05	38.69	38.67	32.09
1000	21.23	33.08	39.91	39 90	33.10
1100	21.52	34.04	41.06	41.02	34.05
1200	21.79	34.92	42.11	42.05	34.91

in cal./g-mole, or Pcu/lb.-mole, are shown in Figure 2 as a function of the Centigrade temperature. The mean molar heat capacity above the ice point is given in Table 11 for the Centigrade scale and in Table 12 for the Fahrenheit scale.

Cubic equations to represent the heat capacities of the compounds on all four temperature scales are given in Table 13.

TABLE 12

Mean Heat Capacities of Some C_1 Oxygenated Hydrocarbons
Btu./lb-mole • °F.

°F.	Carbon Suboxide	Acetone	iso-Propyl Alcohol	n-Propyl Alcohol	Allyl Alcohol
32	15.05	17.20	20.50	19.78	17.00
60	15.25	17.55	21.09	20.26	17.36
77	15.38	17.77	21.23	20.56	17.58
100	15.54	18.06	21.62	20.94	17.87
200	16.16	19.46	23.13	22.68	19.17
300	16.70	20.57	24.67	24 32	20.43
400	17.19	21.67	26.11	25.87	21.63
500	17.62	22.74	27.50	27.31	22.78
600	18.02	23.77	28.81	28.66	23.86
700	18.39	24.76	30.02	29.90	24.87
800	18.74	25.70	31.14	31.07	25.81
900	19.06	26.59	32.21	32.15	26.71
1000	19.36	27.45	33.23	33.18	27.55
1100	19.62	28.26	34.18	34.16	28.36
1200	19.90	29.02	35.09	35.07	29.12
1300	20.14	29.75	35.96	35.94	29.83
1400	20.37	30.45	36.79	36.76	30.52
1500	20.59	31.11	37.58	37.54	31.16
1600	20 80	31.73	38.33	38.28	31.78
1700	20.99	32.33	39.03	39.00	32.37
1800	21.17	32.91	39.71	39.68	32.93
1900	21.34	33 45	40.37	40.33	33.47
2000	21.50	33.98	41.00	40.95	33.98
2100	21.66	34.49	41.58	41.53	34.47
2200	21.80	34.96	42.16	42.09	34.94

TABLE 13

Heat Capacity Equations for Some C_1 Oxygenated Hydrocarbons

Range: The equivalent of that indicated for the Centigrade Scale.

Equation: $C^\circ_p = a + b(t) + c(t^2) + d(t^3)$

Units: cal./g-mole • °C. or °K.
Btu./lb.-mole • °F. or °R.

Compound	T	a	$b.10^2$	$c.10^5$	$d.10^9$	Range	ERROR Max. Percent	ERROR Avg. Percent
Carbon Suboxide	°C.	15.15	2.052	−1.656	0.5182	0–1200	1.22	0.31
	°K.	8.203	3.073	−2.081	0.5182			
	°F.	14.78	1.173	−0.5197	0.08886			
	°R.	8.203	1.707	−0.6423	0.08886			
Acetone	°C.	17.20	4.805	−3.056	0.8307	0–1200	0.56	0.10
	°K.	1.625	6.661	−3.737	0.8307			
	°F.	16.34	2.730	−0.9566	0.1424			
	°R.	1.625	3.700	−1.153	0.1424			
iso-Propyl Alcohol	°C.	20.50	6.020	−4.069	1.156	0–1200	0.35	0.18
	°K.	0.7936	8.502	−5.016	1.156			
	°F.	19.43	3.434	−1.273	0.1982			
	°R.	0.7936	4.723	−1.548	0.1982			
n-Propyl Alcohol	°C.	19.88	6.383	−4.641	1.414	0–1200	0.90	0.30
	°K.	−1.307	9.235	−5.800	1.414			
	°F.	18.73	3.639	−1.456	0.2425			
	°R.	−1.307	5.131	−1.790	0.2425			
Allyl Alcohol	°C.	17.00	5.018	−3.444	0.9948	0–1200	0.23	0.14
	°K.	0.5203	7.122	−4.259	0.9948			
	°F.	16.10	2.856	−1.080	0.1706			
	°R.	0.5203	3.957	−1.315	0.1706			

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* * *

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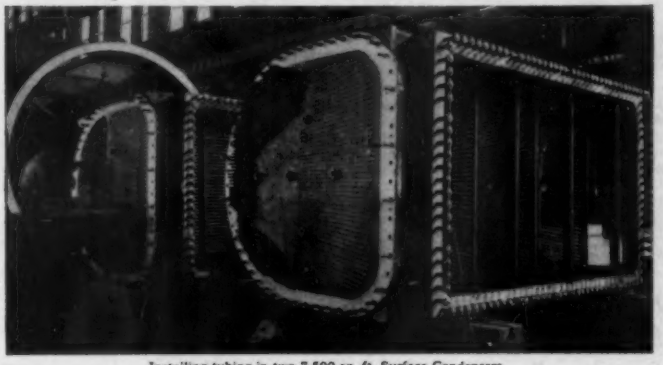

Installing tubing in two 7,500 sq. ft. Surface Condensers.
Courtesy Allis-Chalmers Manufacturing Co.

90-10 Cupro Nickel Condenser and Heat Exchanger Tubing

During the present emergency many users of 70-30 and 80-20 cupro nickel tubing will be faced with the problem of selecting suitable substitutes for these excellent alloys. This is in keeping with the defense program which calls for conservation of nickel for military needs.

Fortunately, for the past few years much work has been done in determining the relative merits of cupro nickel alloys with lower nickel contents. The most promising is 90-10 cupro nickel containing 1% to 1.75% iron. This alloy shows good corrosion resistance in flowing sea water, the iron acting as a corrosion inhibitor. It compares very favorably with 70-30 cupro nickel containing 0.5% iron.

Applications Growing

Appreciable quantities of 90-10 cupro nickel have already replaced Admiralty condenser tubes in surface condensers of power plants using salt water for cooling purposes. Results to date have been very encouraging.

Where 90-10 cupro nickel has been tried out in oil refineries, it has shown superiority over Admiralty from the circulating salt water side although it is not as satisfactory as Admiralty when in contact with hydrogen sulphide and similar components. Admiralty has been the standard alloy for oil refineries for many years, but there has been a move towards changing to more impingement resisting alloys especially among refineries located on the seaboard. Aluminum brass, Duronze IV (aluminum bronze), and 70-30 cupro nickel are now quite common for handling corrosive harbor waters.

In beet sugar evaporators 90-10 cupro nickel has also proven superior to brass, Admiralty, and aluminum brass on the vapor side, which is quite corrosive.

Offsetting Impingement Corrosion

Like the higher-nickel content alloy, 90-10 cupro nickel shows fine resistance to impingement corrosion which is one of the enemies of condenser tube life. Impingement corrosion thins the metal especially at the entrance end of the tubing for a distance of possibly six or eight inches. Sometimes the attack extends throughout the tubes or is localized anywhere along the length of the tube.

The brunt of the impingement attack is at the mouth of the tubing where it receives the full impact of the circulating water. Sea water is a more active solvent than fresh water. The higher the water speed, the more severe the attack.

Effect of Velocity

Some alloys are more sensitive to impingement attack than others. Admiralty brass, which stands up nicely against circulating sea water at low velocities such as four feet per second, may fail rapidly when the water velocity is raised to seven feet per second and higher. The practice of using higher water velocities explains why there is a trend away from Admiralty, which does not stand up well under such conditions. Aluminum brass withstands impingement corrosion better than Admiralty and all of the cupro nickel alloys are also far superior to Admiralty against this type of attack.

In the interest of conservation of materials as well as the investment itself, it pays to give close attention to the selection of the alloys which will give the longest service life and minimum shut-down time. As time goes on, the experience gained from accumulated records of condenser tube behavior pays big dividends. We appreciate the cooperation of operating engineers which has enabled our Corrosion Laboratory to help with corrosion problems. (7113)

REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the processing industry.

Duo With Parallel Careers Collaborate On Current Article

"INTRODUCTION to Chemical Reaction Calculations" on page 83, is the result of collaboration by two Texas A. and M. College professors whose careers have run a fairly parallel course.

G. L. Farrar, an assistant professor in the department of chemical engineering, is a native Texan from Brownfield. In 1942 he received a B.S. in Chemical Engineering with honors from Texas Technological College and he also holds an M.S. from Texas A. and M. and the degree of Chemical Engineer from Texas Tech. He spent five years in the field, gaining experience as a chemical engineer and group leader with the Magnolia Petroleum Company Field Research Department at Dallas, and as chemical engineer for the Socony-Vacuum Oil Company Research and Development Laboratories at Paulsboro, N. J. Since 1947 he has been an assistant professor of chemical engineering at Texas A. and M. engaged in research on catalytic cracking. By no means a long-hair professor, Farrar is a member of the Southwest Football Officials Association and officiates at many football and basketball games. When seeking less strenuous activity he plays contract bridge or chess.

Static issuing from the home of Assistant Professor **A. M. Platt** probably emerges from Platt's amateur radio set for he is an enthusiastic ham and holds a license to operate under call letters W5RA6. A graduate of Carnegie Institute of Technology in 1942, he spent five years with Magnolia's Field Research Department at Dallas, and with Socony-Vacuum's Research and Development Laboratories at Paulsboro, N. J., doing work on oil refining processes. As assistant professor of chemical engineering, he has done research on mass transfer and chemical kinetics problems. Platt possesses considerable talent with hammer and saw and claims to have done about fifty percent of the construction for his three bedroom home. Like Farrar, he enjoys frequent games of contract bridge.

Kali and Newcomers Discuss Wax Moulding By New Process

THE authors of "Continuous Moulding of Paraffin Wax" are V. A. Kalichevsky, well known to PETROLEUM REFINER readers, in combination with Jim H. Beard and Leon H. Jennings who make their debut on these pages. See page 97.

Kalichevsky—or "Kali" as he is usually referred to for ease of speech—has an impressive professional record that began with a chemical engineering degree earned at California Institute of Technology in 1924. For five years thereafter he engaged in chemical research for Union Oil Company, moved on to Standard Oil Development Company, became section supervisor of research and development for Socony-Vacuum in 1931. In 1944 he was appointed consulting chemical engineer for Magnolia Petroleum, a position he still maintains. In May of this year the staff of the Process Control Laboratory presented him with a scroll recognizing his work in starting and organizing the Laboratory work.

Kali's contributions to this magazine alone are too numerous to mention individually, and he has served in many professional organizations.

Educated in the Corps of Pages of the Imperial Russian Court and the General Staff's College in Petrograd, he served as captain of the Imperial Russian Guards during the Russian revolution. Kali and his wife, the former Valentina B. Fedorenko, have one daughter, Kira, who has chosen chemistry as her profession.

Beard, who makes his home in Bryan, Texas, is a graduate of Texas A. & M. in mechanical engineering. He is assistant to the general foreman of the lube plant at the present time but has served as process engineer in the technical department and as supervisory process engineer during his five years with the company.

Beard owns a speedboat and gets a big kick out of cutting through the water at a fast clip. "The Old Man" to his troops during the war when he served as a first lieutenant of infantry, he's much happier to be hailed as "Daddy" by three ever-mischevious sons, aged six, four and one.

Jennings graduated from Tri-State College in Indiana with both B.S. and M.E. degrees and then shoved off with the Navy in 1942 for a three and one-half year hitch as a naval lieutenant. For the past four years he has been a special projects engineer at Magnolia, having spent one of the five years with the company doing zone engineering. Jennings, who is a bachelor and still permitted that recreation, enjoys long afternoons on the beach.

J. H. Beard | L. H. Jennings | G. L. Farrar | A. M. Platt

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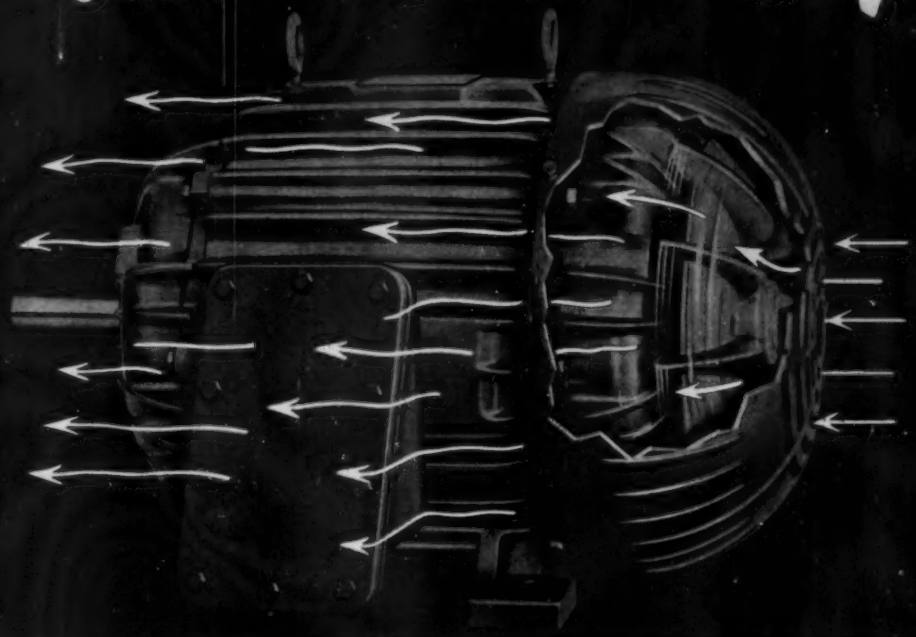

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Humble Oil Men, All Texans, Write on Gasoline Components

THE quartet who prepared "Production of High-Octane Gasoline Components" appearing on page 71, are members of the Refining Technical and Research Divisions of Humble Oil & Refining Company at Baytown, Texas, and incidentally, all are native Texans.

Arthur A. Draeger completed his Ph.D. degree in physical chemistry at the University of Texas in 1935, having previously taken his M.S. in chemical engineering. Employed by Humble since 1935, he has contributed to a number of developments in refining research and process operations. At the present time he is head of the Technical Service Division at Baytown. Draeger is a member of numerous professional societies, and is active in local civic and church affairs.

Gilmore T. Gwin earned his B. A. degree in chemistry from Rice Institute in 1933 and went to work for Humble the following year. At present he is a senior research chemist in the Research and Development Division at Baytown. He has participated in research and development work, including alkylation, polymerization, isomerization, hydrogenation, hydroforming, catalytic cracking and solvent extraction projects. He is a member of several professional societies and is active in local affairs.

C. J. G. Leesemann was unfortunate enough to be given too many initials and too much name, but fortunate on the other hand, for he was born on St. Patrick's day. "Pat" joined Humble in 1940 at Baytown following graduation from Rice Institute with a B.S. in chemical engineering. Married and the father of two girls, his principal hobbies are bowling, deep sea fishing, and making movies of his own brand of "Star-dust." Pat holds three patent rights and several patents are pending to cover devices and discoveries pertaining to petroleum refining. He is a research section head at the present time.

Morris R. Morrow joined Humble in 1940, a B.S. and M.S. graduate in chemical engineering from the University of Texas. A senior research chemist in the Experimental and Testing Division at Baytown, he has specialized in studies on the manufacture and use of fuel products from petroleum, and holds one patent in this field. Several other patents are pending. A member of several professional societies, his hobbies include fishing, bowling, and devising new methods to keep ahead of "a house full of women," namely his wife and two young daughters.

After Class Instructor Engages in "Homework"

PAUL BUTHOD, associate professor in refining at Tulsa University, and the author of "Furnace Operation Variables," found on page 77, used to have a lot of athletic fun playing tennis and ice skating for recreation. But nowadays he takes off for home in high gear after classroom hours to greet his wife and three lively daughters and to take care of handyman repairs. Last year he spent a lot of extra time planning additions to their home.

Born in Tulsa, Buthod attended Tulsa University and received a B.S. degree in refinery engineering in 1939. He worked on pilot plant operations and gas analysis at The Pure Oil Company's laboratory north of Chicago until 1942 when he returned to Tulsa University with a Ethyl Corporation Fellowship. Equipped with a brand new M.S. degree in 1942, he joined the chemical engineering and refining department of the University. In addition to teaching, he has done consulting work in Heat Transfer and Liquefied Petroleum Gas, and in April, 1950, published an article on "Pressure Drops in Gas Vapor Lines" in this magazine.

Paul Buthod

Four Recent Graduates Join Sun Research Unit

Four recent college graduates have joined the staff of the Research and Development Department of Sun Oil Company at Marcus Hook, Pa., as follows:

James R. Calkins, a graduate in chemical engineering of the Massachusetts Institute of Technology.

Peter S. Hepp, a graduate in chemical engineering of the University of Pennsylvania.

Oscar A. Klamer, a graduate in chemical engineering of the University of Illinois.

Eleanor A. Greiner, a graduate in chemical engineering of Drexel Institute, Philadelphia.

NGAA Meeting for 1952 Scheduled for Houston

The 31st annual convention of the Natural Gasoline Association of America will be held in the Rice Hotel, Houston, April 30-May 1, 2, 1952, according to a recent announcement from NGAA headquarters in Tulsa.

Three regional meetings have also been scheduled. The first of these, jointly sponsored by the East Texas Natural Gasoline Men's Club, will be the Southern Regional at the Blackstone Hotel, Tyler, Texas, October 19. The Panhandle-Plains Regional will be held in the Herring Hotel, Amarillo, December 7. The Permian Basin Regional is scheduled to be held in Odessa, Texas, early in February.

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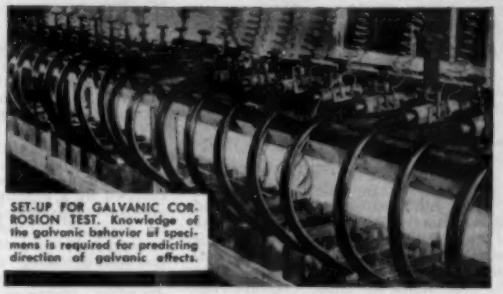
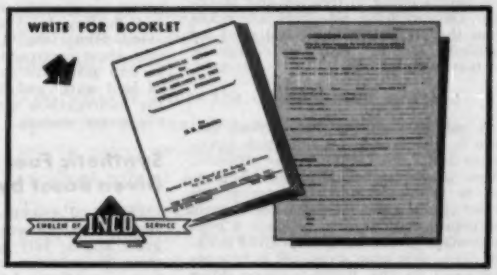
We freely provide the Corrosion Data Work Sheet, illustrated, for presenting your specific problems.



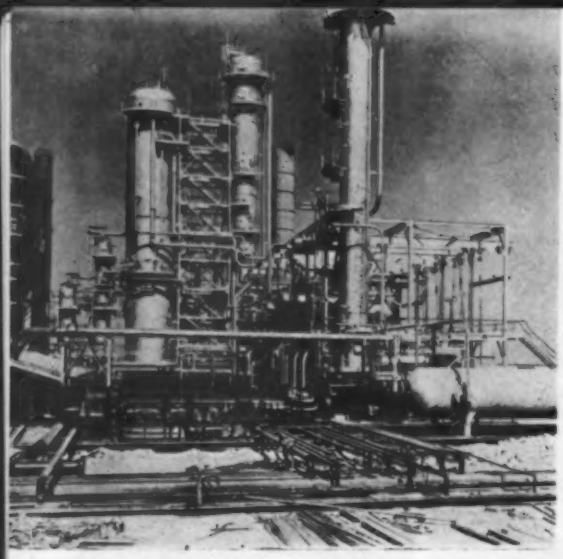
SET-UP FOR GALVANIC CORROSION TEST. Knowledge of the galvanic behavior of specimens is required for predicting direction of galvanic effects.



Whenever you need assistance in solving a corrosion problem, our Corrosion Engineering Section will gladly cooperate with you. A free copy of the new booklet entitled "Metallurgical Methods for Combating Corrosion and Abrasion in the Petroleum Industry" may help you defeat corrosive attacks...write for it now.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

The MONTH... in the INDUSTRY



New Distillation Unit at Bahrein. (See item below)

Bahrein Distillation Unit Finishes Eight-Month Run

Bahrein Petroleum Company's new distillation unit at its Awali refinery on Bahrein Island recently completed its first eight months run, processing 17,570,000 barrels of crude, or an average of more than 72,000 barrels daily. The new unit was designed to operate in conjunction with an existing vacuum distillation unit and to produce a wide range of closely fractionated straight run products from Saudi Arabian crude. Design work by The Lummus Company was essentially completed in little over one year. Construction was by International Bechtel, Inc.

The crude still is a preflash type of distillation unit in which whole crude is first fractionated at a pressure of approximately 60 psig. A light gasoline of from 180° F. to 270° F. end point is taken overhead from the preflash column and routed to a stabilizer within the unit limits for vapor pressure control before going to treating and blending. Two naphtha side cuts are taken from the preflash column and used for gasoline blending, reformer charge or jet fuel manufacture.

Two Flash Zones

A unique feature of the preflash column is that it includes two flash zones, upper and lower, separated by stripping trays. Crude feed to the preflash heaters is split, the portion entering the lower flash zone being heated to a temperature such as to produce a high percentage of overflash. Vaporized material from this zone strips off light ends contained in the liquid coming down from the upper flash zone, the feed to which has been given only a nominal amount of overflash. Bottoms from the preflash column are fractionated in an atmospheric tower, which produces kerosine and diesel distillates and bottoms for charge to the vacuum unit.

Among the unusual features of this crude still is that the combination preflash and atmospheric heater is the largest known process furnaces ever designed and built when considered in terms of heat release on a single setting. The heater is an atmospheric draft design and includes a convection section and steam superheater in addition to end fired radiant sections.

Constructed immediately adjacent to an existing vacuum unit, the new crude still was designed for integrated operation with this unit. Construction work was done without interrupting the vacuum unit operations, and final tie-ins were made during a scheduled maintenance shutdown of the vacuum unit. The integrated operation of these two units made necessary a thorough study of heat exchange equipment with the result that steam generating equipment for waste heat recovery was installed.

Vertical thermosiphon type shell and tube units having double tube sheets and "U" tube bundles were provided for steam generations, the heat being supplied by a kerosine stream from the atmospheric fractionator. Bad feed water available in Bahrein leads to heavy scaling, subjecting the units to severe thermal descaling cycle in operation. The thermal strains encountered in this descaling operation have proven too severe for conventional single tube sheet and floating head equipment to withstand. Hence the "U" tube and double tube sheet construction to provide satisfactory assurance against leakage either of feed water and dissolved solids into the hydrocarbon stream or of oil into the steam system.

Synthetic Fuel Production Given Boost by New Act

Defense Production Act amendments, action on which was completed by Congress late in July, permits the government to subsidize commercial production of synthetic liquid fuels by means of long-term purchase contracts. Installation of further facilities for production of aviation alkylate could be handled similarly. The President signed the bill July 31 although he blasted its "inadequacies."

Secretary of Interior Chapman had indorsed use of the long-term purchase method for fostering a synthetic liquid fuels industry. He is expected to commence negotiations with a private group headed by Ferdinand Eberstadt which wants to build a coal hydrogenation plant in Southern Illinois.

Phillips to Aid Employes Suffering Flood Damage

A plan to assist in the rehabilitation of all Phillips employes, some 1400 in number, who suffered damage to their homes or personal property in the recent floods in the Kansas City area was announced last month by K. S. Adams, chairman, and Paul Endacott, president, of Phillips Petroleum Company.

Under terms of the plan Phillips will contribute money to the extent of half of an employes damage up to a loss of $4000 and provide a non-interest bearing loan for additional funds required to replace the loss. The loans may be repaid by salary deductions over a period of three years. Applications for aid may be submitted to the employe's local manager.

Phillips was the principal refinery casualty in the distaster that swept Kansas City, although the bulk plants and terminals of many other oil companies suffered heavy damage.

CS Appoints Sinsheimer Economics Coordinator

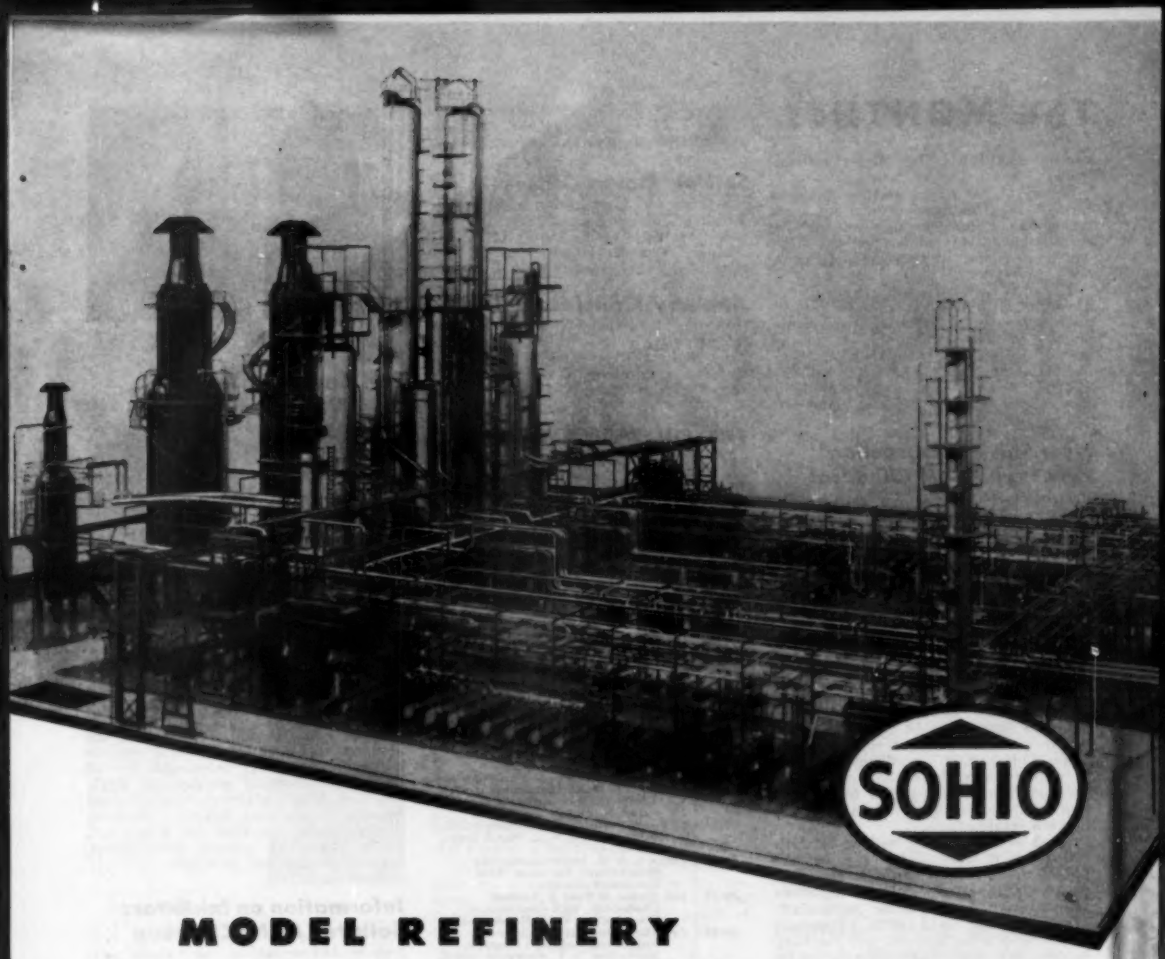
Broad economic studies within the petroleum industry, and long-range growth plans of petroleum subsidiaries and departments will be analyzed by Warren A. Sinsheimer, newly appointed Petroleum Economics Coordinator for the Cities Service organizations. Sinsheimer, vice president of Petroleum Advisors, Inc., a Cities Service affiliate, joined the Cities Service Company in 1917 as a member of the production and engineering department in Oklahoma.

Sinsheimer

A graduate of the University of California, Sinsheimer was one of the group which established the organization now known as the Economic Department of the American Petroleum Institute.

Abadan Refinery Shut Down

Distillation unit 80 was closed on July 31 and the big Anglo-Iranian oil refinery at Abadan was finally and completely shut down. After the Iranians had taken over the nation's oil properties, the refinery operated on a gradually decreasing scale until all storage



MODEL REFINERY

THIS twin combination atmospheric and vacuum unit would fit comfortably into your office. It's an accurate scale model of a 50,000 barrel unit now being built by McKee for Standard Oil Company of Ohio.

The model isn't a toy—it's a valuable engineering tool that helps check engineering and speed up construction. By enabling McKee estimators, purchasers, engineers and construction crews to see plant details in miniature it saves valuable time in interpreting plans, in instructing field personnel and in specifying and ordering materials and equipment.

For Sohio it offers the opportunity to train operating and maintenance personnel, and to set up safety procedure. In addition it is an excellent exhibit for public relations purposes.

This is another example of McKee's constant effort to improve refinery design and speed construction in the field.

DESIGN, ENGINEERING AND CONSTRUCTION FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

McKee Engineering

Arthur G. McKee & Company • Established 1905

Headquarters: McKee Building, 2300 Chester Avenue, Cleveland 1, Ohio. *New York:* 30 Rockefeller Plaza, New York 20, N.Y. *Tulsa:* 918 First National Bank Building, Tulsa 3, Okla. *England:* The Iron and Steel Division of Arthur G. McKee & Company, is represented by Head, Wrightson & Co., Ltd.

The MONTH . . .

had become full. Then the shutdown came.

Supply of 100-octane aviation gasoline is probably the most critical oil item facing the British as a result of the curtailment of shipments from the Abadan refinery, according to Asiatic Petroleum Company.

The British during the week of July 23 added 1 million barrels to the 14 million barrels of refined oil products already purchased in the U. S. to export to areas in short supply from Abadan. The purchases, negotiated by Asiatic Petroleum Company, were made at Gulf Coast and East Coast refineries.

New Solvent Extraction Process by Dow Chemical

Development of a new process for the extraction of aromatic concentrates for aviation gasoline, benzene, toluene and xylenes from petroleum was announced last month by The Dow Chemical Company, Midland, Mich.

The new process, named "Udex," was developed in cooperation with Universal Oil Products Company, Chicago, who will act as its licensing agents to the petroleum and petro-chemical industries.

According to Dow spokesmen, the Udex process effects a substantially complete separation of these necessary aromatics. Recovery of the aromatics from wide-boiling petroleum naphthas is exceptionally high, and the Udex product "can be separated by distillation to produce benzene and toluene of high quality."

Used in conjunction with a catalytic reforming process, Udex can be employed to extract maximum quantities of aromatics from reformed naphthas. It has been found to be particularly effective when used with Universal's new Platforming process, and the combined Platformer Udex unit is singularly practical from an operating economy standpoint, the spokesman declared.

Colorado Shale Oil Used By Denver Switch Engine

Diesel fuel made from shale oil in the Bureau of Mines' Oil-Shale Demonstration Plant near Rifle, Colo., was used during June and July by a railroad switch engine in the Rio Grande yards, Denver.

For the first time, a thorough five-week road test was made with this fuel, and A. E. Perlman, general manager of the Rio Grande, and J. H. East, Jr., regional director of the Bureau of Mines, jointly announced that it was a complete success.

Unsaturated Hydrocarbons Blamed for Coast's Smog

Unsaturated hydrocarbons are the major uncontrolled source of smog in Los Angeles County, Air Pollution Control Director Gordon P. Larson announced in a report to the Board of Supervisors in July.

"Current investigations will determine how much of the unsaturated hydrocarbons are entering the atmosphere and how they react in the air to form their portion of the smog," Larson said. "Control of these important contaminants will be zealously sought."

Sinclair Moves Offices

Sinclair Oil Corporation and Sinclair Refining Company are moving into the new Sinclair Oil Building, 600 Fifth Avenue, New York, with the transfer scheduled to be complete by mid-August.

Appleby Transfers to SOD

Walter G. Appleby, former senior technologist in Shell Oil Company's New York offices, recently transferred to Shell Development Company as a research chemist in colloid chemistry.

THE OIL MAN'S CALENDAR

AUG. 13–14	LP-Gas Engine Fuel School, Lafayette, Ind., Purdue University.
13–15	SAE, National West Coast Meet. Seattle, Olympic Hotel.
17	WPRA Regional, Alma, Mich., Leonard Refineries, Aud.
SEPT. 3– 7	American Chemical Society, Annual. N.Y. Hotel Statler. 120th Nat'onal Diamond Jubilee.
5– 8	Oil Industry Information Committee, N.Y., Waldorf-Astoria.
8– 9	Int. Union of Pure & Applied Chemistry, 16th Conference, N.Y., Hotel Statler.
10–13	Int. Congress of Pure & Applied Chemistry. 12th Conference, N. Y., Hotel Statler.
10–14	Instrument Society of America, Sixth National Instrument Conference and Exhibit, Houston, Sam Houston Coliseum.
11–13	International Discussion on Postwar Heat Transfer Development with ASME Administrative Coordinator, London.
12–14	National Petroleum Association, Atlantic City, N. J., Hotel Traymore.
13–14	Texas A. & M. Instrumentation Symposium, Houston, Sam Houston Coliseum.
14–15	Int. Union of Pure & Applied Chemistry, 16th Conference, Washington, D.C., Hotel Statler.
16–19	American Institute of Chemical Engineers, Regional Meeting, Rochester, N.Y. Sheraton Hotel.
20–21	WPRA Regional, Casper, Wyo., Hotel Henning.
24–26	ASME. Sixth Petroleum Mechanical Engineering Conference, Tulsa, Mayo Hotel.
25–28	American Society of Mechanical Engineers, Fall. Minneapolis, Minn., Hotel Radisson.
OCT. 4– 5	California Natural Gasoline Association, 26th Annual. Los Angeles, Ambassador Hotel.
8– 9	Texas Mid-Continent Oil & Gas Association, Annual. Beaumont, Texas. Hotel Beaumont.
8–10	The American Oil Chemists' Society, Fall. Chicago. Edgewater Beach Hotel.
8–12	National Safety Council, 39th National Safety Congress and Exposition. Chicago. Stevens Hotel.
14–20	Oil Progress Week.
15–17	American Gas Association, Annual. St. Louis, Kiel Auditorium.
18–20	National Association of Corrosion Engineers, South Central Region. Corpus Christi, Texas.
22–24	American Standards Assn., Annual. New York, Waldorf-Astoria Hotel.
NOV. 5– 8	American Petroleum Institute, Annual Convention, Chicago, Stevens Hotel.
25–30	American Society Mechanical Engineers, Annual Meet, Atlantic City, Chalfonte-Haddon Hall.
26 to Dec. 1	Exposition of Chemical Industries, New York, Grand Central Palace.
DEC. 2– 5	American Institute Chemical Engineers, Atlantic City, Chalfonte-Haddon Hall.

White

Hopkins

Pan American Refining Picks White for Research

Appointment of Dr. P. C. White as manager of research and development for Pan American Refining Corporation was announced August 1 by L. W. Moore, president. Dr. White will make his headquarters at the company's main research laboratories in Texas City, Texas.

Dr. White comes to Pan American from the Research Department, Standard Oil Company (Indiana), Whiting, Ind. His research experience has covered many fields, including thermal cracking, alkylation, hydrocarbon synthesis and pilot plant work. In 1950, Dr. White was appointed Division Director, Fuels and Special Products Division at the Whiting Laboratory.

Mr. C. Hopkins, previously Coordinator of Research and Development, has assumed the duties of technical director and will be directly responsible for all phases of chemical engineering work. Dr. J. E. Kasch advances from assistant director to associate director. Working directly under Hopkins, Dr. Kasch will be in charge of process development, process design and economics.

Information on Inhibitors Solicited by NACE Group

New information on inhibitors, whether derived from laboratory research or from field experience is being collected by Technical Practices Committee 9 on Corrosion Inhibitors, one of the technical committees of the National Association of Corrosion Engineers. Contributions ranging in size from one-page observations to complete papers will be received by the committee chairman, Aaron Wachter, Shell Development Company, Emeryville 8, Cal. Papers received will be discussed critically by the committee and then issued in collected form with discussion as a report of the committee.

Natural Gasoline Changes Announced by Phillips

Several recent changes in the administration of the natural gasoline department of Phillips Petroleum Company have been announced as follows:

Roy M. Teel named assistant to the manager of the department, George P. Bunn.

H. R. Legatski, superintendent of operations, named project development engineer for Phillips Chemical Company, a Phillips Petroleum subsidiary. Louis P. Sumpter becomes superintendent of operations.

W. L. Culbertson appointed chief engineer in charge of the engineering division succeeding Teel; C. R. Ringham

appointed director of the section of coordination and analysis of the engineering division succeeding Culbertson; L. H. Moore appointed superintendent of the division of contracts and settlements, with R. H. Clark to direct the settlement section; H. R. Markley named assistant to Sumpter in charge of plant operations, and W. L. Phillips named western district superintendent at Odessa, Texas, to succeed Markley.

Research Men Promoted By Standard of Indiana

Standard Oil Company (Indiana) has announced five promotions on its research staff. The members promoted and their new positions are R. F. Marschner, senior research associate; B. L. Evering, research associate; A. P. Lien, section leader; and D. R. Carmody and C. E. Johnson, group leaders. All are located at Standard's Whiting, Ind., research laboratory.

Evering

Marschner

Lien

Dr. Marschner was graduated from Brown university and received a Ph.D. from Penn State college in 1936, joined Standard's research staff in 1934 and has been a section leader since 1946. Dr. Marschner is the new chairman of the ACS Chicago section.

Dr. Evering, who received undergraduate training at Loyola college, of Baltimore, and the University of Heidelberg and a Ph. D. from Johns Hopkins university in 1934 has been a research staff group leader since 1943.

Dr. Lien was graduated from Ottawa, Kans., university and received a Ph. D. from Ohio State university. In 1941 he joined Standard and has been a group leader since 1946.

Texaco Promotes Dr. Coppoc

Dr. W. J. Coppoc has been promoted to associate director of research in The Texas Company's Technical and Research division, headquarters New York. Dr. Charles E. Moser has been named to succeed Dr. Coppoc as assistant director of research at the company's Research Laboratories, Beacon, N. Y.

Dr. Coppoc received his Ph.D. from Rice Institute in 1939, returned to the company that year, and was transferred to Beacon in 1947.

Dr. Moser received his Ph.D. from Northwestern in 1939 and joined the company the same year. He has been supervisor of the Fuels Development Research department at Beacon since 1948.

Continued Decline Shown By Motor Gasoline Survey

Further lowering of research octane ratings of representative gasolines in the U. S. and Canada was reported in the July, 1951, Motor Gasoline Survey conducted by E. I. du Pont de Nemours & Company.

Downward trend of the ratings was pointed up by the fact that premium gasolines in only four of the 48 cities included in the survey showed improved octane ratings, while those in 22 cities declined from the levels published in Dupont's April survey.

The number of cities with premium gasolines of 90-plus octane ratings similarly fell off sharply, from 28 in April down to 22 in July. In these cities, too, the rating was lowered in all but one, which remained the same as in April. Tests of regular gasolines likewise showed a decreased octane rating, with only ten reporting 85 or above, compared with 16 in April.

Continued tetraethyl lead shortages, held responsible for the lower octane ratings, caused a decrease of TEL content in both premium and regular gasolines in 39 of the cities tested. However, in the nine cities where premium gasolines had a higher average TEL content, only three showed a resulting improved octane rating.

The "Motor Gasoline Survey," published by Dupont as a quarterly marketing information service, furnishes current data on antiknock rating and TEL content of motor fuels marketed at retail outlets in 43 cities in the U. S. and five in Canada.

Coal Regaining Position As Fuel, Chamber Reports

Stability of coal prices as compared with oil and gas may be the decisive factor in the improving position of coal in the fuel market, a U. S. Chamber of Commerce Natural Resources department report indicated.

Possible production of synthetic fuels from coal was also pointed out as a basis for optimism in the coal industry. The Iranian situation also has a bearing, in that if oil from that country were lost to the western world, it would be up to coal to make up for the fuel shortage caused by increased U. S. oil exports. The coal gas-turbine locomotive may supplant the diesel, the coal industry believes.

A great advantage held by the coal industry is that known reserves of coal are good for "hundreds of years," the Chamber concluded.

Kimberlin Is Named Esso Senior Research Associate

Charles N. Kimberlin, Jr., has been named senior research associate, according to Alex Voorhies, Jr., director of the Esso Laboratories, Esso Standard Oil Company, Louisiana Division. Kimberlin's elevation, Voorhies said, is in line with the policy of conferring professional titles upon employes who have rendered distinguished service in technical fields.

Kimberlin

Associated with the Esso Laboratories since 1933, Kimberlin's achievements, the announcement stated, have been in the fields of chemical and petroleum research leading to the development of new catalysts and to the development of improved processes for the conversion of petroleum raw materials to more valuable products.

The new senior research associate received the B. S. degree in chemistry from Louisiana College in 1931 and the M. S. degree in organic chemistry from Louisiana State University in 1933, shortly before joining the Esso Laboratories.

Engineers Study Warren Blast to Determine Cause

A group of "technical experts," headed by H. Emerson Thomas, is investigating the explosion and fire which caused damage estimated up to $5 million at Warren Petroleum Corporation's Port Newark LP-gas terminal in early July. Findings of the study, which is being

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1950:									
January 28	4,950	5,470	248,411	18,363	124,270	7,302	66,337	8,389	57,036
February 25	5,000	5,277	245,586	17,703	133,888	6,890	56,056	7,855	48,662
March 25	4,848	5,469	244,227	17,839	135,406	6,870	40,577	8,171	42,546
April 29	5,014	5,314	244,744	18,038	128,055	6,531	36,686	7,272	39,260
May 27	5,118	5,591	240,852	18,704	122,757	7,301	40,607	7,421	39,308
June 24	5,355	5,636	240,762	19,026	115,036	6,868	50,580	7,461	41,291
July 29	5,323	5,870	240,234	19,941	109,076	7,266	61,437	7,870	42,252
August 26	5,699	6,197	236,934	20,263	105,793	7,539	65,941	8,543	41,597
September 30	5,903	6,051	241,631	19,624	104,383	8,460	76,734	8,306	42,330
October 28	5,895	6,051	244,805	19,878	105,063	8,259	84,057	8,449	44,310
November 25	5,888	6,238	244,497	19,847	106,424	8,591	88,768	8,470	45,586
December 23	5,763	6,159	250,799	20,075	112,631	9,436	78,273	8,718	39,914
1951:									
January 27	6,066	6,483	244,220	21,106	126,201	9,984	58,997	9,985	40,378
February 24	5,954	6,524	237,204	20,815	136,870	10,545	48,764	9,471	38,995
March 31	6,041	6,381	235,956	20,396	142,186	9,365	43,170	9,147	37,282
April 28	6,154	6,236	242,479	19,876	137,474	8,061	43,859	8,747	36,080
May 26	6,163	6,430	246,400	21,102	130,819	8,580	51,344	9,045	37,365
June 23	6,192	6,549	247,599	22,107	127,736	8,806	62,959	9,295	40,647
July 21	6,166	6,406	249,012	21,363	122,104	8,731	74,686	8,963	44,140

The MONTH...

conducted in cooperation with Warren engineers, will be made available to the LP-gas industry and to all government agencies and other interested parties.

Thomas, who is head of H. Emerson Thomas and Associates, Westfield, N. J., has had more than 20 years' experience in engineering and safety matters in connection with LP-gas.

California NGA Names McLaren 1951 President

New officers were elected for the California Natural Gasoline Association at the annual meeting held recently.

George C. McLaren, general superintendent of Southern District Natural Gasoline Department of Standard Oil Company of California, was elected president, while Warren H. Kraft, director of Honolulu Oil Corporation was named vice president. E. R. Millett, Jr., was reappointed secretary-treasurer.

The following were appointed to serve on the executive committee: F. E. Bradley, C.C.M.O.; C. L. Case, Continental Oil Company; R. C. Enderly, Wilmington Gasoline Company; Fred Hartley, Union Oil Company of California; Ray Hull, California Research Corporation; C. L. Hutchings, Tide Water Associated Oil Company; E. W. Walker, Western Gulf Oil Company; P. E. Foote, Petrolane, Ltd.; M. L. Fort, Pacific Lighting Gas Supply Company; Grove Lawrence, Southern California Gas Company and Wilton J. Heinz, Ingersoll-Rand Company.

World Co-Op Is Suggested

An operating company in Iran, jointly owned by consuming countries, was urged by Howard A. Cowden, president and general manager of Consumers Cooperative Association, as a solution to the confusion in Iran.

Conferees in Iran are overlooking a "golden opportunity" if they fail to establish such a co-op, Cowden said. Cowden sent a proposal to President Truman in which he suggested creation of an international oil co-op to produce, refine, transport and market Iran's crude and products from the Abadan refinery.

Lion Names Ben Smith

Ben S. Smith, Jr., has been named director of industrial relations for Lion Oil Company, El Dorado, Ark., replacing John W. B. Foringer who has resigned.

Smith

A native of Mexia, Texas, Smith received his education in the public schools of Mexia, Metropolitan Business School in Dallas and Rice Institute of Houston.

He became associated with Lion Oil in April, 1937, at the time the company acquired the assets of E. L. Smith Oil Company of Mexia. After work in several other departments, he transferred to the personnel department in 1942 and has been an assistant personnel director since 1947.

Champlin

Wolf

Kellogg Company Names Two New Vice Presidents

Two new vice presidents, one to head sales and the other to take charge of the company's manufacturing facilities in Jersey City, have been named by The M. W. Kellogg Company, New York.

Russell J. Wolf, formerly assistant to President Warren L. Smith, has been named vice president in charge of sales. He will also continue to supervise Canadian projects as a vice president of Canadian Kellogg Company, Ltd.

Formerly general manager of the Equipment Manufacturing Division of Continental Can Company, Donald W. Champlin is the new vice president in charge of Kellogg's manufacturing. His responsibilities include Kellogg's volume in fabricated metal equipment for refinery, chemical and electric utility firms.

Pure Oil's Toledo Plant Scene of Group Promotion

A group of promotions in The Pure Oil Company's Toledo refinery transferred David S. Frank, refinery manager, to Chicago as assistant manager of the Refinery Technical department. He will specialize in utilities. Frank has been superintendent and manager of the Toledo refinery for the past six years.

Hal H. Dronberger succeeded Frank as manager, moving up from general superintendent, a post held since 1947.

William S. McConnor, superintendent of construction and maintenance, succeeded Dronberger.

Victor H. Trumpy, became superintendent of operations, a new position. He advanced from the position of general operating foreman.

Willard G. Dailey, of Heath refinery, was appointed superintendent of maintenance and construction.

Jack Allen was moved to Toledo as staff assistant from the Heath plant in Newark, Ohio, where he was special assistant.

Plant Maintenance Show Is Moved to Philadelphia

The Plant Maintenance Show, staged for the first two years in Cleveland, Ohio, will be held January 14-17, 1952, at Convention Hall, Philadelphia. Because of a total of 156 companies have already contracted for exhibit space, according to the management, and the move east is expected to draw greater attendance from industrial areas in that section.

Concurrently with the show the Plant Maintenance Conference will be held with L. C. Morrow, consulting editor, Factory Management and Maintenance, the chairman.

Lubrication Specialist Is Promoted by Texaco

Gus Kaufman has been named assistant manager of the Technical and Research division of The Texas Company, Dr. Wayne E. Kuhn, division manager, has announced.

Kaufman is a lubrication specialist, whose work during World War II won him a Naval Ordnance Development award. He is the author of many patents and publications on lubricatiing greases, cutting oils, gear lubricants, and allied subjects.

He was graduated from Rice Institute, Houston, in 1924, and was employed by The Texas Company shortly thereafter. During the past ten years he has served as staff technologist and assistant to the manager of the Technical and Research division, New York.

Doe Run Chem Plant Nears August Completion Date

To follow the final stages of construction and prepare the plant for initial operation, J. G. Woods, manager of Mathieson Hydrocarbon Chemical Corporation's plant at Doe Run, Ky., and his staff have moved from Boston to Doe Run. The corporation is a recently organized company composed of Mathieson Hydrocarbon and Tennessee Gas Transmission interests.

A. L. Willie, who has been resident manager at Doe Run for Mathieson Hydrocarbon, will return to Mathieson Chemical Corporation at Baltimore, on the staff of Carl F. Prutton, vice president and director of operations.

Initial operations for the production of petroleum products is expected to begin in August. TGT has already finished a stripping plant at Gabe, Ky., and this plant is connected to the Doe Run plant by a 60-mile pipe line constructed by Mathieson Chemical Corporation.

Production will fall into two general classifications both of which are vital to the defense effort: organic chemical products and petroleum products.

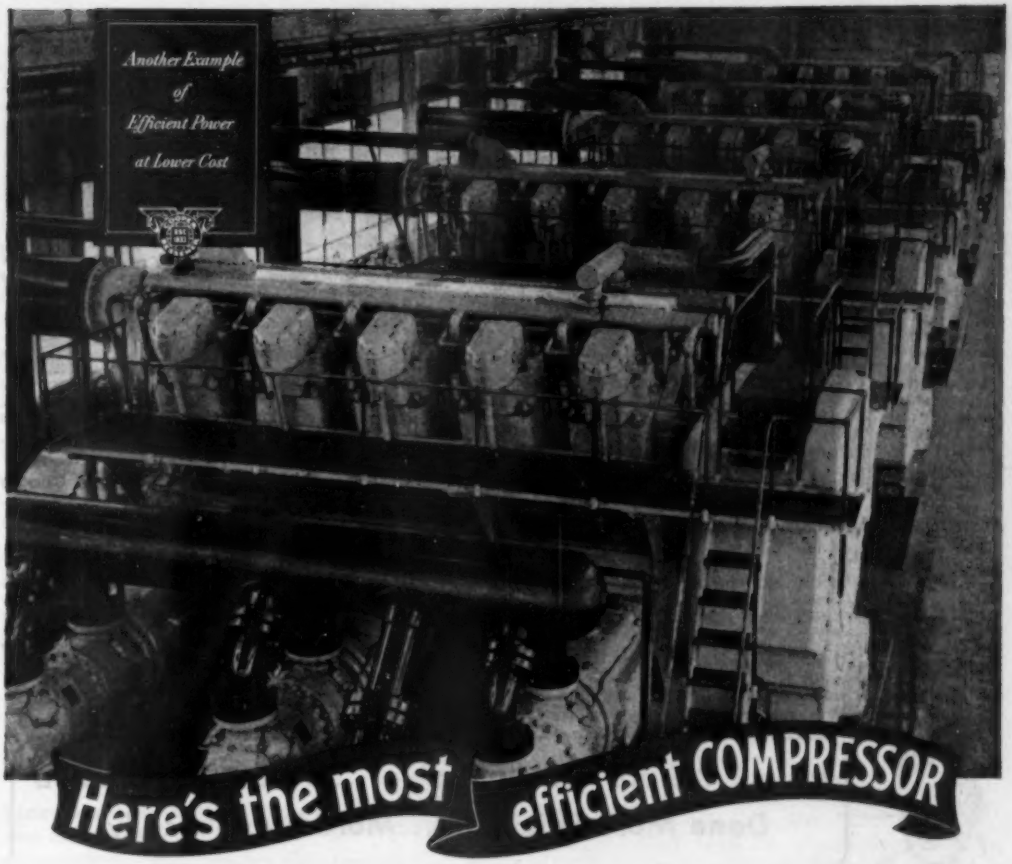
Mineral Wool Industry Will Certify Products

The Industrial Mineral Wool Institute, New York, on July 1 activated an industry-wide certification program designed to assure standard quality and protect industrial users of mineral wool products. Each carton or section of insulation manufactured by the Institute's member companies will carry a label certifying that its properties exceed minimum requirements prescribed in two commercial standards issued by the National Bureau of Standards (U. S. Department of Commerce).

The Institute includes 16 leading manufacturers of mineral wool insulation, with plants in all sections of this country and Canada.

Improved Distribution May Offset Low Steel Allotment

Tonnage allocations of steel for the oil industry in the fourth quarter are considerably less than the industry had hoped for, but it is believed that an improved distribution system may relieve inequities. During the third quarter, oil and other industries were unable to utilize allotments fully because of supply maldistributions, which should



Here's the most efficient COMPRESSOR

MAYBE you've been thinking about compressor sizes and types you'll be needing for jobs ahead. You are aware that new developments in the oil and gas industry require you to study carefully the advantages and disadvantages of all types of equipment. Of one thing you can be sure . . . the GMW compressor unit (a recent development in itself) takes *full* advantage of the biggest strides made in gas engine performance. So in your planning weigh and compare these significant facts:

FUEL EFFICIENCY

1. The GMW is the only gas engine that guarantees fuel consumption of 7500 BTU's per BHP/hr. This means that the fuel you save operating these engines is delivered to the consumer . . . additional profit for you!

INSTALLATION EFFICIENCY

2. On installation, piping, housing, over-all operation, and maintenance you can save plenty with the GMW the largest angle compressor built. It offers the lowest *space-to-power* ratio of any gas engine driven compressor unit today, necessitating fewer units on gas transmission lines.

SMALLER COOLING TOWERS

3. Extra savings, big ones, are assured on the cost and installation of cooling equipment and piping alone, *because the GMW has the lowest heat dissipation of any gas engine compressor unit on the market today!*

These are just a few of the major economies you'll gain with modern, long-lived, low-maintenance GMW's. If your plans call for compressor power from 1500 bhp up, get *all* the facts . . . ask the nearest Cooper-Bessemer office to give you specific performance figures and estimated savings based on your particular requirements.

The
Cooper-Bessemer
Corporation

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

New York, N. Y. Washington, D. C. Bradford, Penna. Parkersburg, W. Va.
San Francisco, Calif. Houston, Dallas, Greggton, Pampa and
Odessa, Texas Seattle, Wash. Tulsa, Okla. Shreveport, La.
St. Louis, Mo. Los Angeles, Calif. Chicago, Illinois Caracas, Venezuela

The MONTH...

grow less severe as the Controlled Materials Plan goes into full operation.

The amount of steel allocated to the oil industry is 1,806,500 tons, which is 328,500 tons below PAD's estimated "minimum" requirements, and nearly 600,000 tons under actual needs.

A breakdown of the allotment shows that the production industry will receive 485,000 tons, and 200,000 tons will go for oil field machinery and equipment, leaving a remaining 1,121,500 tons for other branches.

In addition to steel, oil was given for the fourth quarter 7,975,000 pounds of copper and 785,000 tons of aluminum. The oil industry is also involved in allotments of steel to other industries, such as the Engine and Turbine Division, with 461,000 tons, which will handle storage tanks. It will also get about 55 percent of the 285,000 tons allocated for steel drums.

The total fourth quarter allotment for oil is 213,500 tons more than the amount set for the third quarter.

Monaghan Named Director

Thomas E. Monaghan, an attorney with Standard Oil Company (New Jersey), has been elected a director of Esso Export Corporation. A member of Jersey Standard's legal staff for the past five years, Monaghan previously was counsel for Pan American Petroleum & Transport Company and served as a director of The American Oil Company and Mexican Petroleum Corporation.

158 YEARS OF SERVICE—Out of 378 annuitants at the East River Operations, Brooklyn, N. Y., Socony-Vacuum Oil Company, Inc., more than half were guests of company executives recently at a luncheon. For those present, the years of service totaled 6487 for an average of 33.79. These five men, all over 80 and with 158 years of service, were special guests. From left to right, Antoni Biernaczki, Charles Schell, Levi North, James Deaton and Thomas Bowes.

Cities Service Appoints Landa to Economics Post

Maynard I. Landa has been appointed associate petroleum economics coordinator for Cities Service Company. An engineering graduate of Texas A. & M. College, Landa joined Cities Service as a junior engineer in 1919. After serving in the Production department in Oklahoma, Arkansas and Texas, he was transferred to New York in 1925 to make special analyses studies of petroleum operations. In 1941 Landa was made manager of the Petroleum Economics and Statistics department handling these studies.

PAD Refining Head Named

C. E. Davis, vice president in charge of manufacturing for Shell Oil Company, will become director of PAD's Refining division September 1. He succeeds Reid Brazell, who returns to the presidency of Leonard Refineries, Alma, Mich. Davis joined PAD August 1 as deputy director.

Gulf Promotes James Drake

James F. Drake, Jr., has been appointed assistant to the vice president, Product Development and Product Engineering, for Gulf Oil Corporation, Pittsburgh.

Drake first joined Gulf in 1937, then went with the aircraft industry for seven years before becoming lubrication engineer for Gulf in 1948. He has been chief fuels and lubricants engineer, marine engine section, automotive products engineering, since 1950.

Drake's new duties will be to corre-

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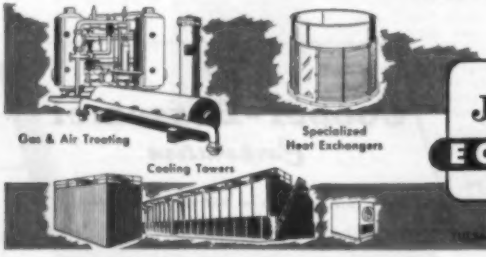

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The MONTH...

late and coordinate activities between the vice president and all sections of the department as well as with the Manufacturing, Sales, and Research departments.

Purvin

Gertz

Robert L. Purvin Becomes Firm of Purvin & Gertz

With the inclusion of Melvin H. Gertz as partner, the firm of Robert L. Purvin, consulting chemical engineers, will be known as Purvin and Gertz, Consulting Engineers. Personnel of the engineering organization will be unchanged and offices will be maintained at 510 Reserve Loan Life Building, Dallas.

Gertz has been associated with the firm for the past four years as process consultant and project engineer. Prior to that time he was employed on the engineering staff of Humble Oil & Refining Company. The firm will continue to specialize in process design, control engineering and operating management, as well as economic evaluations and appraisals in the oil, gas and petrochemical industries.

Standardization Meetings Are Scheduled for October

The National Standardization Conference will concentrate on the part standards are playing in national defense when it holds its second annual meeting October 22-24 in the Waldorf-Astoria, New York. The American Standards Association will hold its 33rd annual meeting in conjunction with the Conference.

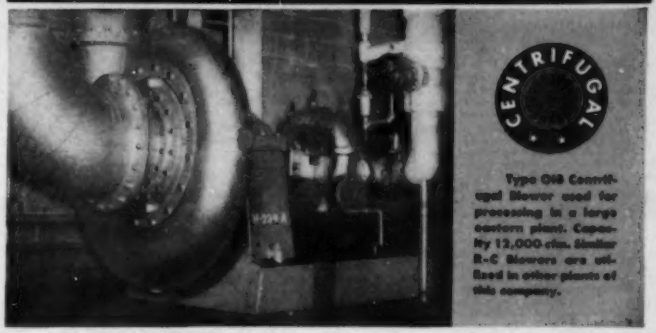
The 1951 award of the Howard Coonely Medal, given annually to a leader in any field who has made an outstanding contribution to national standardization as an instrument of free enterprise, is scheduled at the final luncheon.

Returned to Chicago

David S. Frank, manager of The Pure Oil Company refinery at Toledo, Ohio, since 1945, returned to Chicago recently as assistant manager of the refinery technical department.

A-C Official Dies

William C. Johnson, 49, executive vice president of Allis-Chalmers Manufacturing Company, died suddenly on Thursday morning, July 26. He was a member of the firm's board of directors and also a member of the executive committee of the board. In addition, Johnson served as chairman of the board of Canadian Allis-Chalmers (1951) Ltd.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New Catalogs AND EQUIPMENT LITERATURE

For copies of the catalogs and new equipment literature listed, use one of the convenient Reader Service Postcards on this page. Just circle the number on the card corresponding to the number of the item in which you are interested.

Steam Economy

Information regarding efficient use of steam is contained in the manual "How Increasing Your Steam Costs Can Save Money" which is published for Sarco Company, Inc. The booklet contains 16 questions and answers, all slanted to executives in the industrial and heating fields. A list of Sarco bulletins also is enclosed looseleaf for further information.

Circle No. 1 on Postcard

Gas Burners

The Denver Fore Clay Company has announced issuance of Catalog No. 300 containing specifications and engineering data on the complete line of DFC gas burners and accessory equipment. Detailed data and diagrammatic drawings of various types of installations and engineering tables of high and low pressure gas capacity of inspirator orifices are included.

Circle No. 2 on Postcard

Rotary Pump

Warren-Quimby Rotex pumps are illustrated in both sectional and exterior views in a new eight-page bulletin. Dimensions, selection chart and specifications are included.

Circle No. 3 on Postcard

Electro-Chemical Technology

Technical bulletin Number B51-2, "Fundamentals of Industrial Electro-Chemical Measurements and Automatic Control," was released by Minneapolis-Honeywell Regulator Company, Brown Instruments Division. The bulletin deals with the measurement of pH, redox, and conductivity in industrial control systems. Fundamental principles of electro-chemical measurements as well as final control elements for automatic control systems are included.

Circle No. 4 on Postcard

Industrial Traps

A variety of traps for steam, air and gasoline are described in W. H. Nicholson & Company's new 32-page catalog. Included are capacity tables, installation diagrams, and a section containing data, charts and formulae for determining the proper size trap for specific applications.

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New Catalogs AND EQUIPMENT LITERATURE

Use one of the free and convenient Reader Service Postcards on this page to request copies of the catalogs in which you are interested.

Chemical Data

Bulletin 50-1 for the process industries by Infilco Incorporated is "prepared for those men of industry who are charged with the responsibility of investigating and selecting products for chemical handling and processing." Of especial interest to the refining industry are prevention of corrosion in cracking stills, and water softening for special refinery requirements. Chemical treatment and results are given.

Circle No. 6 on Postcard

Pre-Fabricated Piping

Western Piping Supply Division of The Lummus Company has prepared a bulletin "pre-Fabricated Piping," which discusses advances made in the field of high and low-pressure piping subassemblies. It deals with pipe bends, coils, headers, manifolds, Vanstone work, process piping, and welded assemblies produced by the Division for power generation, refining, pipe line transmission and chemical industries.

Circle No. 7 on Postcard

Dehumidifiers

Industrol Corporation's Bulletin DD-130 on dynamic dehumidifiers for instrument air describes them as being compact, economical and rugged. Made for fully automatic or semi-automatic operation, each unit is equipped for electric regeneration. Air drying cycles vary from six to eight hours. Units are available in nine models with capacities ranging from 35 to 200 scrm air at 100 psig and 70° F. Pressure drops range from 2½ to 4½ psig.

Circle No. 8 on Postcard

Sales and Cost Analysis

Punched-card service offered by Remington Rand Inc., is explained in a bulletin. The only manual operation in the procedure is the original punching of the cards. Sorting, reproducing, interfiling and segregating, tabulating and printing of reports are all done automatically.

Circle No. 9 on Postcard

Croloy Tubes and Pipe

"The Properties and Methods of Working Seamless and Welded Tubes and Pipe of B&W Stainless Croloys" is offered by The Babcock & Wilcox Tube Company. Intended for engineers, designers and fabricators, it serves as a guide in choosing proper material and as a help in planning the conversion of stainless steel tubing into finished products for industry. Leather bound booklet is handy 8 x 5 inch size.

Circle No. 10 on Postcard

Rust-Control Measures

A program for removing and preventing rust of petroleum equipment is described in a special service report published by Oakite Products, Inc. Rust control procedures to be followed under varying conditions are discussed in the four-page bulletin.

Circle No. 11 on Postcard

(More Literature Items on Pages 137, 139, 141, 143 and 145.)

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Pneumatic Valve Positioner

The newly designed Cono Rotomotor for operation of catalyst slide valves on throttling control services is manufactured by Conoflow Corporation. It operates through a gear drive and threaded stem and is basically a self-locking mechanism. Positioning device (B), see photo, determines actual valve stem position by means of tape and cam connection (A), and desired stem position by air impulse from control instrument. Corrected output air pressure from (B) then is fed to auxiliary pilot (C) which ports main air supply to pneumatic motor (D) driving gear box clockwise or counterclockwise repositioning stem and completing pneumatic control loop.

Circle No. 12 on Postcard

Oxifiers and Filters

Mercury oxifiers and gold adhesion filters manufactured by Bethlehem Apparatus Company are described in a folder dealing with the principles of operation, etc. The three laboratory outfits listed are general laboratory set with a 25-pound oxifier and type "F" filter; the small set deals with a five-pound oxifier and type "G" filter; the large industrial set carries a 150-pound oxifier and a type "H" filter.

Circle No. 13 on Postcard

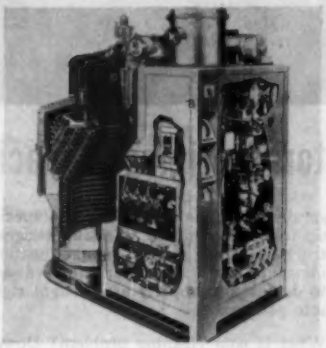
Portable Pyrometers

Descriptive bulletins by Wheelco Instruments Company, deal with two portable pyrometer models suitable for plant and laboratory. Of great utility where temperatures of molten aluminum, zinc, lead, tin, brass and other non-ferrous alloys must be measured before pouring, etc., the models "give rugged, lightweight and accurate performance."

Circle No. 14 on Postcard

Steam Generator

Vapor Heating Corporation has announced that the Vapor-Clarkson steam generator Model 4740 developed to supply large quantities of high-pressure dry steam, is ready for industry to supply processing steam, operate pile driving rigs, laundries, heating, and 600 pounds pressure steam, etc. For size and weight this is termed a most powerful steam generator which develops 200 pounds steam pressure in two minutes from 50° water and produces 4800 pounds of 99 percent dry steam per hour, 82 percent efficient. It uses No. 2 fuel oil. Steam pressure may be changed from 75 to 600 psi by turning one control. There are many safety controls such as steam temperature limit control, stack temperature cut-out, safety valves, electric flame control, time delay relays, etc.



Circle No. 15 on Postcard

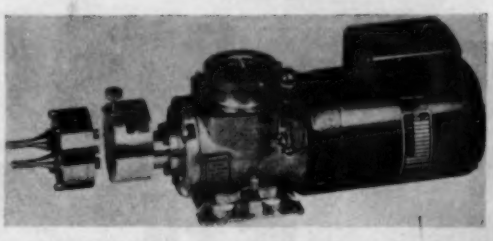
Steam and Air Traps

Data on steam traps and air traps made by Armstrong Machine Works are included in a condensed 12-page catalog. Cast semi-steel and forged steel inverted bucket traps, compound steam traps, ball float air traps, Y-type strainers and internal check valves are listed.

Circle No. 16 on Postcard

Small Metering Pumps

Small stainless steel metering pumps made by the Mechanical Productions Corporation are particularly adaptable for metering small volumes of solutions in a laboratory or for dispensing controlled volumes of liquids in processing operations. The pumps are effective in handling hot or cold, viscous or non-viscous liquids such as oils, grease, wax, and corrosive chemicals. They are precision built, provide "positive displacement action which delivers a smooth, non-pulsating flow of liquids." Pump heads are sterilizable and instantly demountable.



Circle No. 17 on Postcard

Non-Exploding Driver Units

Two new UL approved explosion-proof driver units have been developed by Racon Electric Company. Model XP-1 is approved for use in Class I, group C & D locations, including industries working with ether, ethylene, cyclopropane, etc. Model XP-2 is approved for use in Class II, group E, F, and G locations, which include industrial dust hazards such as magnesium, coal, carbon, starch, etc. The driving units for both models are housed in non-corrosive aluminum casting. A removable back cover plate gives access to the driver unit. Drilled and tapped holes internally provide for inclusion of line matching transformers up to 30-watt capacity.

Circle No. 18 on Postcard

Precipitator

Installation of a 25,000-cubic-foot wet Cottrell Precipitator for the Filtrol Corporation plant at Los Angeles, is underway by the MacIsaac, Menke & Roach, Inc. The new precipitator is designed as an addition to the plant's product drying system and is intended to recover all products in the exhaust gas steam which would otherwise pass through to the atmosphere. Operating on the electro-static principle the precipitator is designed to charge all entering particles with high voltage electricity, collect them on an electrode, and subsequently wash them away in solution.

Circle No. 19 on Postcard

DOWELL SERVICE

CHEMISTRY APPLIED TO MAINTENANCE CLEANING PROBLEMS

This Chemical Company asked:

"Can you restore tower operating efficiency?"

Dowell Service restored original capacity IN ONE DAY!

A fractionating bubble-cap tower, operated by a southern chemical company, contained heavy deposits of iron sulfides, oxides and organic material. These deposits covered the trays and clogged the bubble-caps reducing capacity from 800 to 500 gallons per minute. *Fast, efficient* Dowell Service cleaned this tower in one day. Result: tower was restored to its original 800 g.p.m. capacity.

Dowell Service methods can be applied to many different kinds of refinery and chemical equipment *without dismantling and with a minimum of downtime!* Special liquid solvents designed to dissolve and disintegrate the deposits are pumped or sprayed into the equipment. No special scaffolding is required. Specially designed truck-mounted tanks, pumps, heaters, mixers and control equipment necessary to do the job properly are brought right into your plant.

What is *your* cleaning problem? Dowell Service has extensive experience in cleaning towers, cooling systems, heat exchangers, steam generating equipment, condensers, pipe lines, cooling jackets and many other types of industrial equipment. Call upon Dowell experience and equipment to help increase production. Dowell engineers will be glad to give FREE consultation. Phone the nearest Dowell office.

Other recent Dowell jobs:

All exchangers and towers in a southwestern chemical plant were cleaned by Dowell Service during a complete plant turnaround. Result: Plant turnaround time was cut from fifteen to six days.

•

Over 11,000 feet of 10 to 16-inch diameter fresh water service lines in an oil refinery were cleaned by Dowell Service. Result: Water lines were restored to designed capacity.

•

The Slurry-to-Feed heat exchangers in a fluid catalytic cracker were Dowell Serviced. Result: Company was able to increase through-put from 16,000 to 22,000 bbls. per day.

DOWELL INCORPORATED • TULSA 3, OKLAHOMA

CALL

New York 20, Boston 16, Philadelphia 2, Baltimore, Wilmington 99, Richmond 19, Jacksonville 7, Atlanta, Buffalo 2, Cleveland 13, Pittsburgh 19, Detroit 2, Chicago 4, St. Louis 8, Indianapolis, Louisville, Kansas City 8, Wichita 2, Oklahoma City 2, Houston 2, New Orleans 12, Ft. Worth 2, Shreveport 69, Anniston, Alabama, Mt. Pleasant, Mich., Hamilton, Ohio, Charleston, W. Va., Salem, Illinois, Borger, Texas, Midland, Texas, Wichita Falls, Texas, Lafayette, La.

Long Beach, Oakland, Casper: Dowell Associate—International Cementers, Inc.

★ *Maintenance cleaning service for industrial heat exchange equipment.*

★ *Chemical services for oil, gas and water wells.*

★ *Magnesium anodes for corrosion control.*

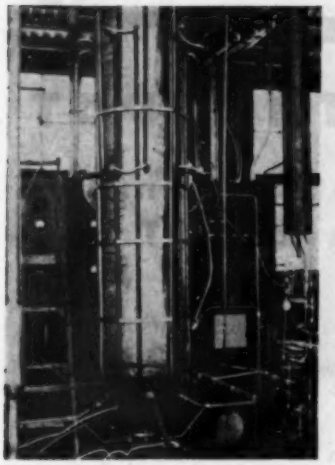
DOWELL

A Service Subsidiary of

THE DOW CHEMICAL COMPANY

To obtain additional data use free Reader Service Postcard opposite page 137. Circle number on card corresponding to number listed at the end of each item on which more data or literature is wanted.

Electric Heat for Cat



Use of electric heat in a pilot catalytic cracker at a major Texas oil company is said by Edwin L. Wiegand Company to provide quick heatup, exact process heat and easily duplicated temperatures up to 1100° F. Mounted on the surface of the cracking vessel are a number of evenly spaced Chromalox alloy-sheathed tubular heaters, with triangular cross-section that provides a flat, contact surface for better heat conduction. Stainless steel bands hold the heaters in position. The photo shows the heaters before insulation was installed. Heaters vary in length and are curved to fit contours at the top and bottom of the vessel.

Circle No. 20 on Postcard

Automatic Humidity Control

Minneapolis-Honeywell has developed a humidity sensing element to operate with the ElectroniK potentiometer, thereby providing percent relative humidity records that are direct, with greater response speed due to primary element sensitivity. Direct readings are made possible by the ability of the machine to record humidity on a potentiometer-type instrument which eliminates the need to interpret wet and dry bulb readings from psychrometric charts.

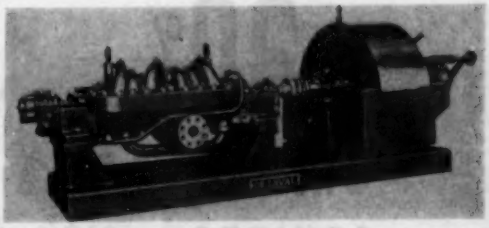
Circle No. 21 on Postcard

Laboratory Services

A folder describing the inspection and testing services offered by Shilstone Testing Laboratory, Inc. covers services offered in works concerned with asphalt, biological, building units, cargo surveys, concrete, fertilizers and farm soils, foods and feeds inspections and tests.

Circle No. 22 on Postcard

Impeller Pumps



Multi-stage opposed impeller pumps are the newest equipment offered by De Laval Steam Turbine Company. Designed for general medium pressure and temperature service up to approximately 1000 gpm and 1200 psi for temperatures 350° to 400° F., they are especially well suited to boiler feed service, oil refinery services for handling liquids ranging from propane to strong caustic and general water services. The "Oppeller" pump has a horizontally split casing with suction and discharge nozzles on opposite sides of the lower half of the casing. Impellers are mounted back to back to balance axial thrust. Volutes are staggered 180° to balance radial thrust.

Circle No. 26 on Postcard

Chain Drives and Conveyors

"Installation, Operation, and Maintenance of Chain Drives and Conveyors" is a handbook published by Chain Belt Company of Milwaukee. The table of contents enables the reader to turn to the specific information with ease. Divided into five major sections, the handbook discusses installation and operation; care of sprockets; lubrication; inspection and storage; and adjustment and repair.

Circle No. 23 on Postcard

Process Equipment

A catalog dealing with equipment subject to corrosion, heat or abrasion conditions, is published by Electric Steel Foundry Company. Equipment is grouped into categories possessing corrosion, abrasion, or heat resistant characteristics and by special processing fields. Production and inspection facilities are outlined.

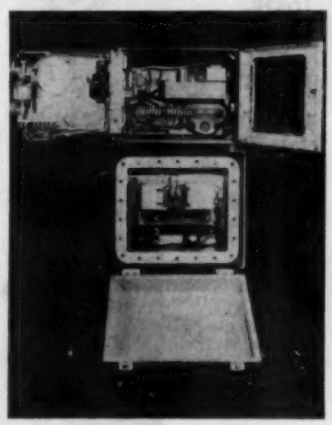
Circle No. 24 on Postcard

Fire Extinguisher

The Rockwood T-head, a development for "more efficient use of water in fire extinguishing" was designed for use in fixed piping systems and can be used as either a sealed or open head. The sealed head combines the principles developed in Water-FOG with the sturdy construction of the figure four fusible elements of the regular Rockwood sprinkler head. The T-head breaks the water into a fog pattern "fine enough to completely fill the area from the ceiling to the floor and heavy enough to drive the particles down to any fire on the floor."

Circle No. 25 on Postcard

Gas Analyzer



For plant stream service Baird Associates offer a completely redesigned continuous analyzer termed "more rugged and compact and designed to permit easy accessibility for servicing." Other features claimed are increased stability and accuracy over long periods and improve sensitivity and higher resistance to shock and adverse temperature and humidity conditions. Two explosion-proof models are available. The redesigned unit provides a continuous quantitative analysis for a single infrared absorbing component in a stream of gas.

Circle No. 27 on Postcard

Tools

"Installation and Maintenance Tools" is the name of Bulletin 451, issued by Key Company. Material includes information required when ordering expanders, covers the Key line of installation and maintenance tools.

Circle No. 28 on Postcard

. . . . . WE Guarantee 30% EXTRA THRUPUT

when your gasoline plant columns are equipped with Koch Kaskade Trays!

THESE REFINERS REPORT EXCEPTIONAL RESULTS

SKELLY
5'-0" diameter, 265# psig. absorber handling 33MM.CF/D and 500 gpm lean oil with 45.5% tray efficiency, basis IC_4. and 73.3% tray efficiency, basis NC_4. Koch Kaskade trays were installed on 26" spacing.

THE TEXAS COMPANY
Obtained increased thruput on 3'-0" diameter. 285# psig. stabilizer to capacities of:

	LIQUID	VAPOR
Volume	450 gpm	0.80 to 2.5 CF/S
Density #/CF	33.1	3.48

Koch Kaskade trays were installed on existing supports—18" to 24" spacing—now operating with excellent results.

WARREN
Obtained increased capacity of a 3'-6" diameter, gasoline plant depropanizer to:

	LIQUID	VAPOR
Volume	471 gpm	7.09 CF/S
Density #/CF	21	2.64

Koch Kaskade replacement of bubble trays, using existing support rings on 24" spacing, has increased the thruput with a bonus of increased separation efficiency.

IT WILL PAY YOU TO INVESTIGATE THE ECONOMY AND OPERATING EFFICIENCY OF KOCH KASKADE FRACTIONATING TRAYS. *Write us today. No obligation.*

THE KOCH ENGINEERING COMPANY, INC.
DESIGNERS ▪ MANUFACTURERS ▪ BUILDERS
335 WEST LEWIS STREET ▪ WICHITA 2, KANSAS

Eastern and Export
30 Rockefeller Plaza
New York City

Pittsburgh, Pa., Repr.
D. D. Foster Co.
412 Peoples Gas Bldg.

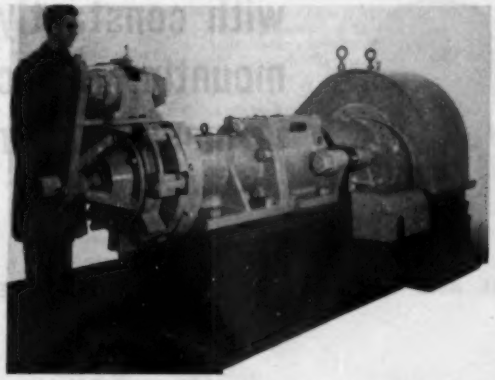
Tulsa, Okla., Repr.
Myers-Bogwell Co.
Wright Bldg.

British Associates
Messrs. A. F. Craig & Co., Ltd.
Paisley, Scotland

To obtain additional information or literature use free Reader Service Postcard opposite page 137. Circle number on card corresponding to number listed at end of each item on which more data or literature is wanted.

Clay Pelletizer

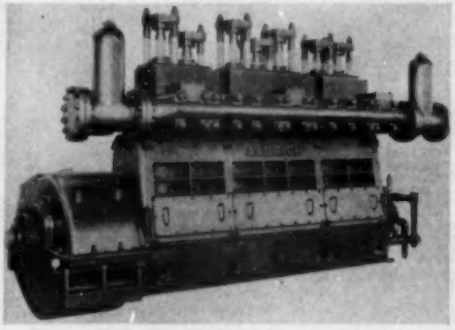
The extruding machine shown here is designed especially for pelletizing clay, a new application now added to the many for which Farrel-Birmingham Company, Inc., screw-type machines are built. This extruder consists of a specially designed screw contained in a steel cylinder. The screw is bored for coolant circulation, and the cylinder, which is lined and jacketed, has a hinged head at the discharge end which supports the pelletizing die and cut-off mechanism. The drive is by electric motor through a Farrel double reduction gear drive. These units are made in several types with screw diameters ranging from 6 to 20 inches.



Circle No. 29 on Postcard

Direct Flow Pump

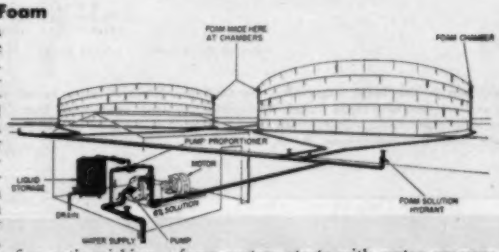
Aldrich Pump Company has added to its line a six-inch-stroke direct-flow pump series which includes triplex, quintuplex, septuplex and nonuplex units, having 3, 5, 7, and 9 plungers, respectively. The six-inch-stroke series ranges from 300 to 900 hp. The pumps operate at crankshaft speeds up to 300 rpm. and are suitable for direct drive by engine or synchronous engine-type motor. Featured are inverted design and a direct flow fluid-end with wearing parts interchangeable within the series.



Circle No. 30 on Postcard

Mechanical Fire Foam

Illustration is of a typical Walter Kidde & Company, Inc. mechanical foam installation for protection of tank stored flammable liquids. Adaptable to either large or small storage tanks, the operation of the system generally depends on normal plant water pressure to draw, mix and deliver the fire extinguishing agent. In large installations where main pressures would be inadequate for the job, special pumping is required. Components of the foam are water, foam liquid, and air. The basic mechanical foam system starts with water pressure passing through pipes or hoses and the velocity of the water creates a vacuum which draws the foam liquid from storage chambers into the stream.



Circle No. 31 on Postcard

Flow Meter

A new type of flow meter which has functional design, gives fast and accurate response over an entire range and features low initial cost and maintenance has been developed by Minneapolis-Honeywell Regulator Company. Engineers of the Brown Instruments Division said the new flow meter includes such important advantages as an evenly graduated meter scale and electronic integration. It is available either as a mechanical flow meter with integral recorder, or as an electrical transmitter to be used with a Brown inductance bridge receiver. The new meter is of the differential type, readily installed on a flow line.

Circle No. 32 on Postcard

Steel Gauge Valves

Edward Valves, Inc., subsidiary of Rockwell Manufacturing Company, has added two new figures to its forged steel gauge valve series, the 152J and 153J in the half-inch size with male inlet. Designed to be a savings to users, the male inlet serves the same purpose as a nipple, or the only unit needed when connecting pressure gauges to pressure tubing or casing. The new valves conservatively rated at 4000 pounds at 150° F. or 600 pounds at 750° F., according to manufacturer's information.

Circle No. 33 on Postcard

Atomic Attack

"How to Prepare Your Plant for Atomic Attack," released by Walter Kidde & Company, Inc., gives factual information about the atomic bomb. The text is a guide to plant management in organizing personnel to cope with possible plant disasters and recommends methods for strengthening plant construction and sustaining production during bomb attacks.

Circle No. 34 on Postcard

Engine-Driven Generators

Elliott Company's bulletin "Elliott Custom-Built Engine-Driven Generators," shows all types and sizes of generators, for adaptation to diesel engines, gas engines, dual-fuel engines, and steam engines of many prominent American engine manufacturers. Special product bulletins are available as well as answers to any specific engineering or application problems regarding such equipment.

Circle No. 35 on Postcard

Defense Manual

"Plant Protection for National Defense," is a revised manual published by Detex Watchclock Corporation. Designed as a training manual, the booklet contains instructive information to guide watchmen, guards, supervising personnel and management.

Circle No. 36 on Postcard

O_2

A REACTIVE AND IMPORTANT CHEMICAL "BUILDING BLOCK"

with constantly mounting applications in many industrial fields

CHEMICAL AND PHYSICAL PROPERTIES OF OXYGEN

Chemical Symbol	O_2
Atomic Number	8
Periodic Group	VI
Atomic Weight	16.00
Molecular Weight	32.00
Molecular Diameter	3.39×10^{-8} cm
Isotopes	16, 17, 18
Allotropes	Ozone (O_3)
Valence	2 and 6
Concentration in Dry Air	20.93%
Boiling Point (atm. press.)	—183.1°C
Melting Point	—218.8°C
Critical Temperature	—118.8°C
Critical Pressure	49.7 atm.
Critical Density	0.430 gm/cc

Vapor Pressure at Various Temperatures:

Pressure mm. Hg	Temperature °C.
0.76	—219.0
7.60	—211.5
76.0	—200.6
190.0	—194.3
380.0	—189.0
760.0	—183.1

Latent Heat of Vaporization	1635.8 cal./mol. @ B.P.
Latent Heat of Fusion	106.0 cal./mol. @ M.P.
Heat of Reaction with Carbon (Coke)	97,000 cal./mol.
Heat of Reaction with Carbon (Graphite)	94,450 cal./mol.
Heat of Reaction with Hydrogen	68,317 cal./mol.

Boiling Points of O_2 - N_2 Mixtures: 1 atm. Pressure

O_2%	BP °K
90	87.7
95	88.9
98	89.9
99	90.6
99.5	90.1

Entropy:	T °K	Cal gm mole °K
1 Atm.	50	12.52
	100	40.58
	150	43.51
	200	45.36
	250	46.84
	273.1	47.75
	298.1	48.64

Molal Volume: 0° C, 1 atm. (g) 22,397 cc

Specific Gravity:	@ 0° C (g)	1.429
	@ —182.5° C (l)	1.14
	@ —252.5° C (s)	1.426
Specific Heat:	82 to 25°C (g)	6.98 cal/gm mol.
	—183° to —209°C (l)	12.62 cal/gm mol.
	—221.8°C (s)	10.74 cal/gm mol.
Coefficient of Thermal Expansion:	0° C to 100° C (g)	3.674×10^{-3}
	—195° C (l)	4.16×10^{-3}

Compressibility Factor: PV = 1.0 @ 1 atm., 0° C

P, atm.	0°C	50°C	100°C	200°C
1	1.0000	1.1638	1.3674	
10	0.9913	1.1796	1.3661	
50	0.9569	1.1642	1.3630	
100	0.9234	1.1520	1.3651	
200	0.9140		1.4000	1.8190
300	0.9423		1.4530	1.8830
400	1.0515		1.5320	1.9610
500	1.1560		1.6230	2.0500

$\frac{C_p}{C_v}$ (atm. pressure)	0°C.	$\frac{C_p}{C_v}$
	15	1.401
	—76	1.415
	—181	1.45

Vanderwaal's Constants: a = 1.360 (liter², atm. mole⁻²)
b = 0.03183 (liters, mole⁻¹)

Solubility in Water: 4.89 cc in 100 cc @ 0° C
2.6 cc in 100 cc @ 20° C
1.7 cc in 100 cc @ 100° C

Viscosity: @ BP (g) 0.00736 CP
@ MP (l) 0.883 CP
@ 0° C (g) 0.0192 CP
@ —193° C (l) 0.245 CP

Moisture Content of Saturated Oxygen .130 gm/ft³ @ 0°C

Thermal Conductivity:	cal/cm-sec-°C
0°C (g)	5.7×10^{-5}
—78.4°C (g)	4.29×10^{-5}
—191.4°C (g)	1.72×10^{-5}

Index of Refraction: —181°C (g) 1.221

Remember that oxygen is the least expensive element available in pure form, and is finding increasing use in more and more fields. As supplier or user, remember that Chemical Plants builds complete production units in all commercial sizes—based on the processes of Gesellschaft fuer Linde's Eismaschinen, A. G.

CHEMICAL PLANTS DIVISION

BLAW-KNOX CONSTRUCTION COMPANY

PITTSBURGH • TULSA • NEW YORK • PHILADELPHIA • CHICAGO • BIRMINGHAM • WASHINGTON, D. C.

To obtain additional information or literature use free Reader Service Postcard opposite page 137. Circle number on card corresponding to number listed at end of each item on which more data or literature is wanted.

Air Pollution Recorder

The Thomas "Autometer," manufactured by Leeds & Northrup for fully automatic analysis and recording of air pollution by SO_2 is available as either an integrating or non-integrating assembly complete with Speedomax electronic recorder. It records continuously actual concentration of sulfur dioxide in parts per million and has many automatic features. Range of equipment, 0 to 5 parts per million, covers concentrations of SO_2 which are of interest in pollution surveys. It makes use of electrolytic conductivity as a means of measurement.

Circle No. 37 on Postcard

Steam Traps

Newest Velan Engineering Company catalog lists modifications and improvements on a steam trap which combines seven devices. The traps are constructed of bimetal material which functions to keep the valve open when steam is in the trap. Type "S" is a strainer variety of all-purpose Universal steam trap; the "Super" Universal steam trap type has greater capacity, carries pressures up to 1400, and temperatures up to 100° F.

Circle No. 38 on Postcard

Cylindrical Mixer

The Simplex Dispersator, manufactured by Premier Mill Corporation, is designed for processing operations where propellers are generally ineffective for speedy emulsification, dispersion and intimate mixing. The Dispersator consists of a cylinder rotating at high speed. Centrifugal force compels the product outwards through narrow slots in the wall of the cylinder under considerable pressure with a two-fold effect: product is sheared at high speed, and columns of liquid emerging from the slots are further sheared upon coming into contact with the slower moving mass of liquid in the mixing vessel.

Circle No. 39 on Postcard

Condensate Return Unit

Compactly designed to occupy a minimum of floor space, the new vertical Roth condensate return units are versatile for appliances up to 8000 square feet EDR at 20 psi. Two sizes cover this range, according to Roy E. Roth Company, the manufacturers. The unit handles water to 210° F. without vapor lock and the new vertical design is particularly intended for installations where the return piping is close to the floor level. It is supplied as a complete assembly including pump in simplex or duplex units.

Circle No. 40 on Postcard

Oxygen Recorder

An indexed Magno-Therm Oxygen Recorder bulletin, published by The Hays Corporation, is divided into five sections, the introduction including application tables as well as how and why the instrument is used. An explanation of how an analysis is made utilizing the paramagnetic properties of oxygen as well as diagrammatic explanations of the Recording Section's operation is included, etc.

Circle No. 41 on Postcard

Creep Stress Data

Creep stress data on tubing steels used in equipment operating at elevated temperatures and pressures is presented on a new data card available from The Babcock & Wilcox Tube Company.

Circle No. 42 on Postcard

Displacement Transmitters

A displacement type liquid level transmitter has been developed by Brown Instruments Division of Minneapolis Honeywell, for connection to a pneumatic receiver-indicator, recorder or controller, to provide closer liquid level control than obtainable by conventional ball float buoyancy type controllers. Increased liquid in detector cages causes greater buoyancy of the displacer and causes displacement in an upward direction. This initiates a succession of reactions until the components of the system are automatically returned to original positions. Decreased liquid causes a reverse action.

Circle No. 43 on Postcard

Stainless Pipe

The Carpenter Steel Company, Alloy Tube Division, is offering lightweight Schedule 5 stainless steel pipe which besides "reducing cost per foot offers a larger inside pipe diameter," same sizes compared. The piping is easily adapted to use with existing lines of tubing or Schedule 40 and 10 pipe. It will handle 150 psi, resists corrosion, is made in standard AISI analyses of stainless steel. Data sheet.

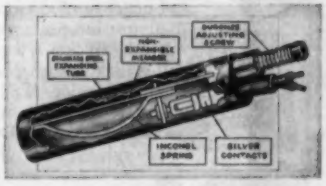
Circle No. 44 on Postcard

Industrial Instruments

Over 100 of the most often demanded Meriam Instrument Company products are described in a new condensed catalog. Among the instruments and accessories described are U type, well type, and multiple tube manometers, inclinometers, draft gauges, liquid level gauges, sight feed bubblers and a complete line of manometer accessories.

Circle No. 45 on Postcard

Expanding Tube Thermostats



The new SCAICO model stainless steel tube thermostat originated by Smith Control & Instrument Corporation, uses stainless steel as the expanding member and an Invar strip as the non-expanding member. An inconel spring gives fast make-and-break action. The Duronze adjusting screw permits quick and easy setting of the control point at any temperature up to 600° F. and elaborate heating or cooling procedure is not required to stabilize it. It is made in three types for conduction, convection or immersion.

Circle No. 46 on Postcard

a a a dries LPG

(ALCOA ACTIVATED ALUMINA)

(LIQUEFIED PETROLEUM GAS)

ALCOA *Activated* Alumina has had a long and successful history of dehydration of liquids and gases. It has been particularly effective in the drying of propane and butane, the gases so important to the production of the new motor fuel, Liquefied Petroleum Gas.

Propane and butane, passed through beds of ALCOA *Activated* Alumina, are freed of their highly dispersed and dissolved liquid water, eliminating the problem of moisture in pipe lines and the hazards of frozen valves. Since ALCOA *Activated* Alumina is one of the few drying agents that will not shatter on contact with water, it is ideal for this operation. Moreover, it will not swell, soften or disintegrate . . . has high resistance to crushing, shock and abrasion . . . is non-toxic . . . non-corrosive . . . practically iron-free.

Years of use have proved ALCOA *Activated* Alumina to be one of the most effective and efficient desiccants available. Dew points as low as *minus* 100° F.—and even lower—have been obtained and under normal circumstances it can be used for an almost indefinite number of drying cycles.

If dehydration is a problem in your process, you will want to know more about this uniformly pure aluminum oxide. We'll gladly send you complete information. Write to: ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 617H Gulf Building, Pittsburgh 19, Pennsylvania.

Alcoa Chemicals

ALCOA

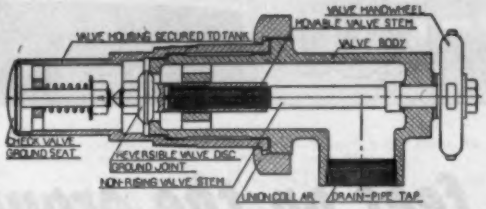
ALUMINAS and FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • HYDRATED ALUMINAS • TABULAR ALUMINAS • LOW SODA ALUMINAS ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE • GALLIUM

To obtain additional data or literature use free Reader Service Postcard opposite page 137. Circle number on card corresponding to number listed at end of each item on which more data or literature is wanted.

Draw-Off Valve

Substantial reduction in the number of frozen valves by refineries using its water draw-off valve is claimed by The Airetool Manufacturing Company. Designed to draw water from storage tank bottoms, it is said to reduce failures due to valves freezing.



The valve is available in both two and three inch sizes to fit two and three inch openings. Construction, see photo, enables the outer part of the valve to be removed for repairs or replacement without draining the entire tank.

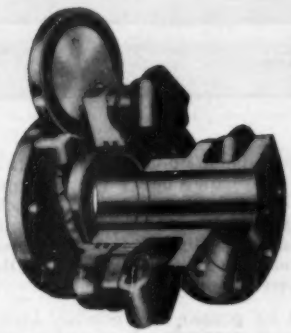
Circle No. 49 on Postcard

Dynamometers

General Electric Company's Type TLC (cradled), 250-volt, d. c. dynamometers for direct connection testing of internal combustion engines, electric motors, pumps, blowers and compressors, is described in a new booklet which also lists dynamometer control and accessories.

Circle No. 47 on Postcard

Line Blind Valve



A "Fluid Saver" line blind valve manufactured by Hamer Oil Tool Company is said to combine spill-proof and self-aligning features with simplified three-bolt operation. The two-piece body possesses telescoping hubs which slide one within the other is designed to provide an enclosed chamber for the spectacle plate and makes the line blind valve resistant to sidewise strains due to misalignment of the piping, or to expansion under pressure or temperature conditions.

Circle No. 48 on Postcard

Pipe Hangers

Blaw-Knox Company has issued a new catalog (No. 51) covering adjustable pipe hangers, vibration eliminators and supports. It contains valuable data for the use of those who buy such materials or write specifications therefor. The technical section offers information needed for a piping engineer to solve most hanger load problems.

Circle No. 50 on Postcard

New Alloy Saves Nickel

The International Nickel Company last month announced the development of an alloy for use under conditions of high temperature and corrosion. The new alloy, trade-named "Incoloy," contains about 35 percent nickel and 20 percent chromium, with the balance iron. It is produced in most standard rolling mill forms, including sheet, strip, rod, wire and tubing. This alloy is designed for many purposes now served by some of the company's older alloys, which run up to more than 70 percent nickel.

Circle No. 51 on Postcard

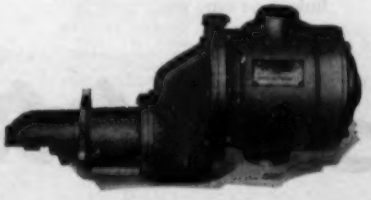
Plastic-Coated Tubing

"Dekoron Instrument Tubing," Samuel Moore & Company bulletin, describes the properties which make plastic-coated metal tubing adaptable where high-corrosion resistance is required.

Circle No. 52 on Postcard

Air-Starting Motors

Air-starting motors for cranking gasoline and diesel engines are manufactured by Ingersoll-Rand Company for use in petroleum, mining, heavy construction, etc. They are designed for cranking diesel and gasoline engines with piston displacements up to more than 35,000 cubic inches. Although normally operated by compressed air, they are also suitable for operation on natural gas at sufficient pressure. Smaller and more compact than equivalent electric starters, the air starter eliminates the necessity of generators, banks of storage batteries, and the costs of battery maintenance and replacement.



Circle No. 55 on Postcard

Instrumentation

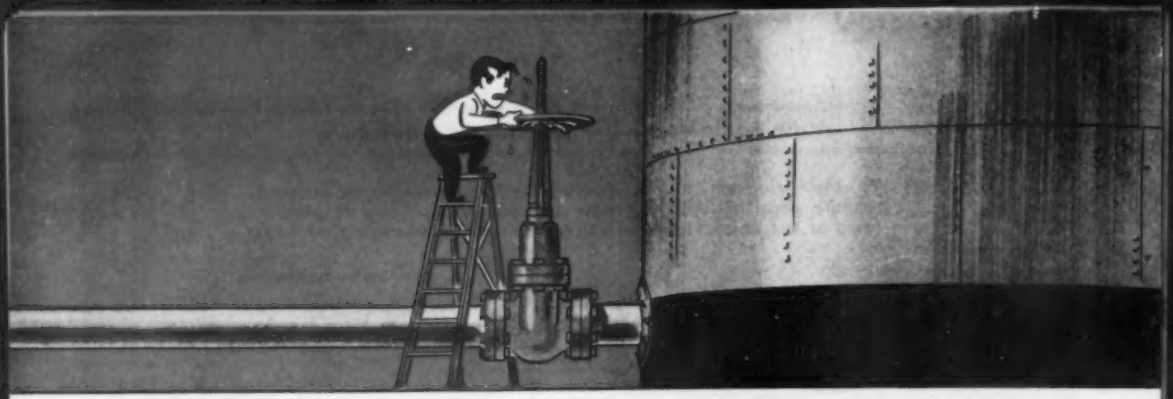
Baird Associates' "Better Analysis," Vol. 2, No. 2, is a periodic review of the theory and practice of instrumentation. The current issue emphasizes the principle of continuous analysis with a detailed description of a plant application.

Circle No. 53 on Postcard

Moving Spent Clay

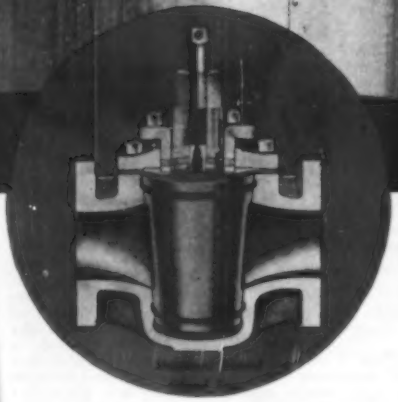
A Schutte and Koerting Company hopper-type eductor, mounted on a movable platform with the hopper located above and the eductor below the platform can be used in decreasing costs for conveying spent clay from filter shells to a settling basin outside the building. Pressure water is used to wash the clay down from the filter shell into the eductor chamber, then pressure water entrains the clay and discharged through hose with force enough to carry the clay-water slurry to the settling basin. Bulletin 2-M.

Circle No. 54 on Postcard



Keep your feet on the ground...

when you turn a tank valve...



Make all tank replacements Nordstroms. By adopting this habit of upgrading your valves you will eventually modernize your tank farm and manifolds with the best in valves at little or no extra cost.

COMPACT You don't have to "climb up in the air" to turn a tank valve if it's a Nordstrom. Its compactness makes operation convenient. No high yoke. Accessible from ground-level. If wrench-operated, only a quarter-turn to close or open; if gear-operated, only a few easy turns of the wheel. In case of line breaks or fire, your operator can shut off a Nordstrom in seconds, which may be the difference between plant protection and disaster.

Your primary tank valves must be positive and reliable. Leaky valves can contaminate the flow in connecting lines and set up unaccounted-for losses. When closed not a drop of line fluid can creep through a Nordstrom because the ports are pressure-sealed and the valve is *automatically lubricated* with Hypermatic to prevent any leakage from even starting.

Nordstrom Valves

NOW AUTOMATICALLY LUBRICATED WITH Hypermatic

TRADE MARK

PATENTS APPLIED FOR

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Atlanta, Boston, Chicago, Columbus, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco, Seattle, Tulsa . . . and leading Supply Houses. Export: International Division, Rockwell Manufacturing Company, 7701 Empire State Bldg., New York 1, N. Y.

Catalogs AND EQUIPMENT *Literature* OFFERED IN THIS ISSUE'S ADVERTISEMENTS

Copies may be obtained easily and without cost by using Reader Service Postcard. Just circle on the card the identifying key number of each item in which you are interested. Postcards are opposite page 136.

TUBE CLEANING AND TUBE EXPANDING TOOLS—Catalog. Airetool Manufacturing Co. See advertisement page 160.
Circle A2 on postcard.

EXPLOSION-PROOF MOTOR—Bulletin 51B6145. Allis-Chalmers Mfg. Co. See advertisement page 15.
Circle A3 on postcard.

HEAT EXCHANGER TUBES—24-page booklet. Aluminum Company of America. See advertisement page 9.
Circle A5 on postcard.

ACTIVATED ALUMINA — Catalog. Aluminum Company of America. See advertisement page 144.
Circle A6 on postcard.

STEAM TRAPS—Catalog H. Armstrong Machine Works. See advertisement page 5.
Circle A11 on postcard.

FIREBRICK—Bulletin R-29. The Babcock & Wilcox Co. See advertisement page 150.
Circle B1 on postcard.

ELECTRONIC RESISTANCE THERMOMETERS —Bulletin 230-C. Bailey Meter Co. See advertisement page 207.
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PIPE & BOLT MACHINE—Catalog C.C.-51. Beaver Pipe Tools, Inc. See advertisement page 206.
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GRATINGS—Catalog. Blaw-Knox Co. See advertisement page 200.
Circle B10 on postcard.

HEAT EXCHANGERS—Bulletin 481. The Brown Fintube Co. See advertisement page 198.
Circle B12 on postcard.

VERTICAL MULTI-STAGE PUMPS — Bulletin 51-6600. Byron Jackson Co. See advertisement page 47.
Circle C1 on postcard.

HIGH TEMPERATURE REFRACTORIES—Booklet. The Carborundum Co. See advertisement pages 60-61.
Circle C2 on postcard.

INSULATION DATA BOOKS. The Philip Carey Mfg. Co. See advertisement page 23.
Circle C3 on postcard.

CHECK VALVES—Catalog. The Chapman Valve Mfg. Co. See advertisement page 191.
Circle C4 on postcard.

TOWER ESCAPE DEVICE—Illustrated folder. Charlie's Machine Works. See advertisement page 202.
Circle C5 on postcard.

STORAGE TANKS—Data. Chicago Bridge & Iron Company. See advertisement page 172.
Circle C7 on postcard.

INSULATION JACKETING—Catalog. Childers Manufacturing Co. See advertisement page 24.
Circle C9 on postcard.

STEAM TRAPS—Data. The Clark Manufacturing Co. See advertisement page 188.
Circle C10 on postcard.

STEAM JET EVACTOR—Data. Croll-Reynolds Co. See advertisement page 211.
Circle D4 on postcard.

INTAKE AIR FILTERS—Bulletin SIF. Dollinger Corp. See advertisement page 35.
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PETROLEUM CHEMICALS LITERATURE—E. I. du Pont de Nemours & Co. See insert 184 and 185.
Circle D10 on postcard.

CENTRIFUGAL CASTING—Catalog 3150. The Duraloy Co. See advertisement page 158.
Circle D11 on postcard.

PACKING HOOKS—Bulletin DHPR. Durametallic Corp. See advertisement page 196.
Circle D12 on postcard.

ALLOY CASTINGS—Catalog. Electric Steel Foundry. See advertisement page 33.
Circle E2 on postcard.

EXPLOSION-PROOF MOTOR—Bulletin. Elliott Co. See advertisement page 125.
Circle E3 on postcard.

TUBE CLEANERS—Bulletin Y-29. Elliott Co. See advertisement page 194.
Circle E4 on postcard.

PRESSURE REGULATOR—Catalog P-10. Fisher Governor Co. See advertisement page 48.
Circle E7 on postcard.

CONTROL SYSTEMS—Literature. The Foxboro Co. See advertisement page 25.
Circle E10 on postcard.

PACKINGS, GASKETS & SEALS—Literature. The Garlock Packing Co. See advertisement page 201.
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ANHYDROUS HYDROFLUORIC ACID—Bulletin 30-A. General Chemical Division. See advertisement page 42.
Circle E12 on postcard.

PREFABRICATED PIPING—Data booklet. Grinnell Co. See advertisement page 193.
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THERMOCOUPLES—Data. Industrial Pyrometer & Supply Co. See advertisement page 170.
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INSTRUMENT CONVENTION AND EXHIBIT —Information. The Instrument Society of America. See advertisement page 195.
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PORTABLE MIXERS—Catalog. International Engineering, Inc. See advertisement page 154.
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"CORROSION DATA BOOKLET"—The International Nickel Co. See advertisement page 127.
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HEAT TRANSFER DATA—Booklet. The International Nickel Co. See advertisement page 20.
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WIRE MESH—Catalog. The C. O. Jelliff Mfg. Corp. See advertisement page 195.
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INSULATING FIRE BRICK—Booklet. Johns-Manville. See advertisement page 6.
Circle G3 on postcard.

HIGH PRESSURE RING GASKETS—Catalog. Johns-Manville. See advertisement page 66.
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HIGH TEMPERATURE HEAT INSULATION—Booklet. Kaylo Division Owens-Illinois Glass Co. See advertisement page 51.
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ASBESTOS-CEMENT STRUCTURAL SHEETS—Catalog. Keasbey & Mattison Co. See advertisement page 41.
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VALVES—Bulletin. Kerotest Manufacturing Co. See advertisement page 40.
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BUBBLE TRAYS—Catalog. The Koch Engineering Co. See advertisement page 140.
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WATER WELL SYSTEMS—Catalog. Layne & Bowler, Inc. See advertisement page 211.
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TEMPERATURE, SPEED AND VOLTAGE RECORDERS—Booklet. Leeds & Northrup Co. See advertisement page 8.
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VALVES—Bulletin. The Lunkenheimer Co. See advertisement page 216.
Circle H3 on postcard.

MIST ELIMINATORS—Bulletin. Metal Textile Corp. See advertisement page 185.
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MIXERS AND AGITATORS—Bulletins. Mixing Equipment Co. See advertisement page 56.
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CORROSION PROBLEMS—Technical Data. Monsanto Chemical Co. See advertisement page 197.
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PIPE COVERING AND BLOCKS—Data Manual. Mundet Cork Corp. See advertisement page 156.
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STEAM TURBINES—Bulletin. Murray Iron Works Co. See advertisement page 153.
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PROTECTIVE TANK COATINGS—Catalog. The Natasco Co. See advertisement page 178.
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COMBUSTION UNIT—Data. National Airoil Burner Co. See advertisement page 190.
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HEAT EXCHANGERS—Catalog section S-6670. National Carbon Company. See advertisement page 148.
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STEAM TRAPS—Catalog 751. W. H. Nicholson & Co. See advertisement page 192.
Circle J8 on postcard.

CLEANING AND DESCALING EXCHANGERS, ETC.—Booklet. Oakite Products, Inc. See advertisement page 183.
Circle J10 on postcard.

HEAT INSULATION—Catalog. Pabco Products Co. See advertisement page 173.
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GAS DRYING SYSTEMS—Data. Pittsburgh Lectrodryer Corp. See advertisement page 32.
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DEHYDRATION EQUIPMENT—Bulletin 16.0.-080. J. F. Pritchard & Co. See advertisement page 184.
Circle K9 on postcard.

COOLING TOWERS—Bulletins. J. F. Pritchard & Co. See advertisement page 154.
Circle K8 on postcard.

VALVES—Catalog. Reading-Pratt & Cady Division. See advertisement page 205.
Circle K11 on postcard.

HEAT EXCHANGER TUBES—Data. Republic Steel Corp. See advertisement page 204.
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DIAL THERMOMETERS—Catalog IT-650. Rochester Manufacturing Co. See advertisement page 206.
Circle L3 on postcard.

VALVES—Literature. W. S. Rockwell Co. See advertisement page 199.
Circle L4 on postcard.

VALVES—Catalog Data. Rockwell Sprinkler Co. See advertisement page 43.
Circle L5 on postcard.

PUMP VALVES—Catalog. Sims Pump Valve Co. See advertisement page 196.
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HEAT EXCHANGERS—Bulletins. A. O. Smith Corp. See advertisement page 11.
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TEMPERATURE & PRESSURE CONTROL SYSTEM—Bulletin 98097. Taylor Instrument Companies. See advertisement page 177.
Circle M3 on postcard.

ADDITIVES—Data. Tennessee Eastman Co. See advertisement page 16.
Circle M4 on postcard.

STEAM TURBINES—Bulletin S-116. The Terry Steam Turbine Co. See advertisement page 203.
Circle M5 on postcard.

PIPE INSULATIONS—Catalog 76-109. Union Asbestos & Rubber Co. See advertisement page 175.
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GASKETS—Data. United States Gasket Co. See advertisement page 151.
Circle M8 on postcard.

REMOTE LIQUID LEVEL GAUGING UNIT—Data. The Vapor Recovery Systems Co. See advertisement page 181.
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PIPE FITTINGS—Catalog F-9. Henry Vogt Machine Co. See advertisement page 189.
Circle M11 on postcard.

DISTILLATION EQUIPMENT—Bulletin. Vulcan Copper & Supply Co. See advertisement page 58.
Circle M12 on postcard.

PIPE FITTINGS—Bulletin S-1. Watson-Stillman Co. See advertisement page 157.
Circle N4 on postcard.

STEAM TURBINES—Catalog. Whiton Machine Co. See advertisement page 206.
Circle N6 on postcard.

STEAM TRAP TRIAL TEST—Information. Yarnall-Waring Co. See advertisement Second Cover.
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"KARBATE" BRAND IMPERVIOUS GRAPHITE HEAT EXCHANGERS *FOR ALL PURPOSES!*

The "Karbate" impervious graphite heat exchangers illustrated are used extensively as boilers, coolers, condensers, vaporizers, evaporators, heaters and absorbers in handling corrosive chemicals, either hot or cold. They *all* can be had in a complete size range. *All of them* offer the following advantages:

- **Highest heat conductivity rate of the practical corrosion-resistant materials.**
- **Highly resistant to corrosion by acids or alkalis, hot or cold.**
- **Freedom from corrosion scale, as compared to metals.**
- **Immune to thermal shock.**
- **No contamination of product.**
- **Strong and easy to install and maintain.**

Shell-and-Tube: Series 70A—Two sizes, 16.4 sq. ft., and 24.6 sq. ft. of outside surface area respecti vely. Tubes easily replaced in the field. Interchangeable single and double-pass construction.

Style FH heat exchangers (Size 1½): Are especially recommended for tanks with solution depths of 16 inches or less. Write for catalog section S-6750.

Series 240A—70.6 feet of outside heat transfer surface. Easy tube replacement. Easily converted on job to single, double, or four-pass tube side flow by simple change of fixed covers. Steel, shell, over-size shell connections, impingement plates and drain and vent plugs integral with shell end castings. Stainless-steel baffles assembled with steel tie rods to form protective cage for tube bundle. Removable "Karbate" tube bundle. Write for catalog sections for S-6690, S-6715 for details of applications, maintenance, sizes and characteristics of these exchangers.

Cascade coolers: For all cooling jobs involving corrosive gases and liquids. Complete cooler assembly may be made quickly from 4 standard items in 5 pipe sizes. Capacity easily enlarged or reduced by adding or subtracting standard sections. Compact construction to save plant room. No special supporting structure needed. Write for catalog section S-6780.

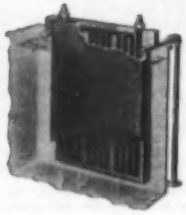
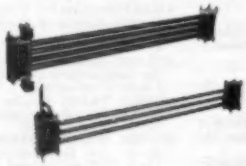


Plate heaters: Used to heat or cool corrosive liquids in tanks and vessels. Compact, completely assembled, easy to put in. Used in pickling, etching, plating and cleaning tanks. Complete size range. Models for horizontal and vertical mounting. Write for catalog section S-6620.



Concentric Tube exchangers: Available in two types. Series 10A is small, low-priced, gives true counterflow. Exceptionally good for small flow rates at narrow temperature differences . . . Series 20A manufactured with "Karbate" inner and outer piping, and is used to transfer heat between two corrosive fluids. Both have sectional construction, can be added to or subtracted from at will. Sturdy, can be moved from place to place after assembly, adapted to any method of mounting on floor, wall, or ceiling. Write for catalog section S-6670.

The term "Karbate" is a registered trade-mark of Union Carbide and Carbon Corporation

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A full line of "Karbate" impervious graphite pipe and fittings

for conveying corrosive chemicals includes: "Karbate" pumps of advanced design embodying impervious graphite case, impeller, and a rotary seal which eliminates the stuffing box. Pump prices reduced up to 33⅓%. Write for catalog section S-7000 for pipe information, S-7200 for pump information.

SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.

The petroleum industry in 1950 achieved its best safety record in its history. The chances of an oil employe being injured fatally or permanently disabled today are about 5900 to 1.

Fundamental Physical and Chemical Data

Heats of Combustion, Formation, and Isomerization of Ten C_4 Hydrocarbons. EDWARD J. PROSEN, FRANCES W. MARON, AND FREDERICK D. ROSSINI. *J. Research Natl. Bur. Standards*, **46** (1951) pp. 106-12. (Research Paper No. 2181.)

The heats of combustion of gaseous hydrocarbons were determined at constant pressure in a flame in a glass reaction vessel contained in a calorimeter. Values expressed in kcal./mole at 25° C. and constant pressure were as follows: butane 687.42 ± 0.15; 2-methylpropane 685.37 + 0.11; 1-butene 649.33 0.18; cis-2-butene 647.65 ± 0.29; trans-2-butene 646.90 ± 0.23; 2-methylpropene 645.19 ± 0.25; 1,2-butadiene 619.93 ± 0.13; 1,3-butadiene 607.16 ± 0.18; 1-butyne 620.64 ± 0.20; and 2-butyne 615.84 ± 0.23. The heats of isomerization, formation, and hydrogenation were derived from the combustion data.

Phase Equilibria in Hydrocarbon Systems. Volumetric and Phase Behavior of the Methane-n-Butane-Decane System. H. H. REAMER, B. H. SAGE AND W. N. LACEY. *Ind. Eng. Chem.*, **43** (1951) pp. 1436-44.

The volumetric and phase behavior of hydrocarbons has proved to be a complex physical phenomenon not well described by simple generalization. The present study is concerned with the characteristics of the methane-n-butane-decane system and was made to add to the experimental background from which more effective generalizations can be drawn. The volumetric behavior of ten solutions of this system were measured at pressures up to 10,000 p.s.i. in the temperature interval 100° to 460° F. The solutions were so chosen in composition as to yield three fixed ratios of n-butane to decane so that the data might be more easily correlated. The compositions of the coexisting gas and liquid phases were determined for equilibrium at 280° F. and values are reported for pressures of 1000, 2000, 3000, and 4000 p.s.i. These measurements completed the study of molal volume as a function of pressure and temperature for the system methane-n-butane-decane in the single phase and heterogeneous regions for volumes smaller than 10 cubic feet per mole. The phase equilibrium measurements confirm that the equilibrium ratio of a component in an aliphatic hydrocarbon solution is greatly influenced by the nature and amount of the other components present. The data together with earlier measurements for the same system afford a background from which the effect of composition upon the constants of an equation of state for such solutions can be evaluated.

Preparation and Physical Properties of a Series of n-Alkanes. ARTHUR K. DOOLITTLE AND ROLAND H. PETERSON. *Jour. Am. Chem. Soc.*, **73** (1951) pp. 2145-51.

The hydrocarbons n-pentane, n-heptane, n-octane, n-nonane, n-undecane, n-tridecane, n-heptadecane, n-octacosane, n-hexatriacontane, n-tetrahexacontane, were prepared by conventional synthetic methods, thus affording a series of ten normal paraffin hydrocarbons covering a molecular weight range of 72 to 900. Most of the compounds as prepared were of high purity and their freezing points, refractive indices and densities were carefully determined as criteria of purity. Densities were determined over a temperature range of —10 to 300° C. Viscosities of the hydrocarbons were measured with great precision from —10 to 300° C. in order to test the validity of certain viscosity relationships over a greater range of temperature and molecular weights than has been heretofore possible. The data and the physical properties of the hydrocarbons are presented in some detail in tabular form and a graph is given covering the viscosity of the n-paraffins.

X-Ray Diffraction Patterns of Solid Aromatic Hydrocarbons. L. J. E. HOFER AND W. C. PEEBLES. *Analytical Chem.*, **23** (1951) pp. 690-5.

Aromatic hydrocarbons of high molecular weight are often difficult to purify and to identify by melting point. However, the x-ray diffraction patterns of relatively impure aromatic hydrocarbons are characteristic. Even minor modifications in structure produce almost completely different powder diffraction patterns. A device for preparing extruded specimens from very small samples, such as 2 or 3 mg., using no permanent binder was developed. The x-ray powder diffraction patterns of 59 hydrocarbons were obtained using iron-target radiation. The patterns of even closely related compounds, or isomers, are unique and can be readily identified. Data are presented in great detail in tabular form. A bibliography of 24 references is included.

Ternary System Furfural-Ethylene Glycol-Water. JOSEPH B. CONWAY AND JOHN J. NORTON. *Ind. Eng. Chem.*, **43** (1951) pp. 1433-5.

It was predicted that furfural would be a good solvent for the extraction of glycol from water, and the present work was undertaken to verify this prediction. The ternary equilibrium diagram for the system, furfural-ethylene glycol-water at 25° C. is presented together with several of the tie lines. Tie-line data were correlated in terms of previously proposed methods. A comparison of equilibrium data, using previously published data for the systems n-amyl and n-hexyl alcohol, indicates that furfural is actually a better extractive solvent for ethylene glycol than either of the alcohols.

These abstracts from the current literature of science and technology (not including trade journals easily available) were prepared by Drs. Leslie and Coats of The Leslie Laboratories, Traver Road, Ann Arbor, Mich., which will supply, at cost, photostatic copies of original articles. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also may be had by arrangement with the laboratories.

Chemical Composition and Reactions

The Exchange Reactions of Normal Paraffins and Unsubstituted Cycloparaffins with Alkyl Halides, Catalyzed by Aluminum Halides. CHARLES P. BREWER AND B. S. GREENSFELDER. *Jour. Am. Chem. Soc.*, **73** (1951) pp. 2257-59.

In the presence of aluminum halide catalysts, hydrogen-halogen exchanges take place between primary, secondary or tertiary alkyl halides and hydrogen attached to secondary carbon atome of normal paraffins or unsubstituted cycloparaffins. Such exchanges were effected using cyclopentane, cyclohexane, propane and normal pentane yielding mainly secondary halides. An olefin and hydrogen chloride can be substituted for a tertiary alkyl halide in the exchange

"B&W Allmul Firebrick keeps saving money for me!"

REORDERED... *for proven, continued economy*

- Welding furnace
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- Butt-weld furnace
- Slag melting furnace
- Dutch oven—French oxide furnace (zinc)
- High BTU gas generator
- Oil fired periodic ceramic kiln
- Car paving material for 3100F kiln
- Electric arc scrap-steel melting furnace
- Lead melting furnace
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- Glass tank—checker chamber
- Glass tank—port neck

Even under very severe service conditions, B&W Allmul Firebrick wins repeat orders! That's because this remarkable, electrically-fused mullite firebrick is low in cost . . . due to a special mass production process developed by B&W engineers.

Allmul stays on the job, too. It is designed to withstand temperatures up to 3200F with unequalled hot load strength. It has high resistance to spalling and slag. As a result, Allmul eliminates need for frequent furnace relining, cuts maintenance and saves valuable production time.

Investigate the money saving possibilities of B&W Allmul Firebrick. The sooner you start using Allmul, the greater your ultimate savings will be. SEND FOR NEW BULLETIN R-29.

ALLMUL *is another important refractories development by B&W engineers who have continuously established new standards in industrial furnace refractories for the past 30 years.*

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reaction. The reaction involves the production of a carbonium ion from the normal paraffin or cycloparaffin through removal of a hydride ion from a secondary position in the molecule. The results of the work extend the application of the carbonium ion theory of acid-catalyzed hydrocarbon reactions to important classes of compounds for which experimental evidence has not previously been available.

Hydrogenation of Petroleum Nitrogen Bases. R. J. MILLER. *Ind. Eng. Chem.*, **43** (1951) pp. 1410-14.

The investigation was undertaken in an effort to convert the nitrogen bases extractable from cracked petroleum into potentially useful intermediates and derivatives. Nitrogen bases studied were extracted from thermally cracked California petroleum by treatment with 45 percent aqueous sulfuric acid, followed by purification of the extract. The compounds were reduced to secondary amines by using sodium and alcohol, by electrolytic reduction, and by catalytic hydrogenation. The variables of electrolytic reduction and of catalytic hydrogenation were studied and the conditions for maximum conversions and yields were established. Derivatives of the hydrogenated petroleum nitrogen bases were found to be useful as vulcanization accelerators, lubricating oil additives, Diesel fuel additives, flotation reagents, fungicides, insecticides, for removal of sulfur from hydrocarbons, and as dewaxing solvents. A bibliography of 21 references is included.

Hydrogenolysis of Thiophene over Vanadium Oxide. V. I. KOMAREWSKY AND E. A. KNAGGS. *Ind. Eng. Chem.*, **43** (1951) pp. 1414-18.

The investigation was undertaken to determine the action of a pure vanadium oxide catalyst on pure organic sulfur compounds under hydrogenating conditions at atmospheric pressure. The work was largely directed towards the study of the hydrogenolysis of theiophene, and to the mechanism of this reaction. Vanadium oxide is an effective hydrogenation catalyst, the activity of which is not diminished by organic sulfur compounds. The results of the work established that the hydrogenation of thiophene represents a true stepwise hydrodesulfurization process. The mechanism of the reaction is discussed as an indication of what may be expected in terms of practical hydrodesulfurization. It was found that a 5 percent solution of thiophene in benzene was desulfurized at 400° C. and atmospheric pressure to the extent of 74 percent, representing a reduction in sulfur from 1.9 to 0.6 percent. The apparatus and procedure used in the work are described in some detail. A bibliography of 15 references in included.

The Reactions of Hydrogen and Deuterium Atoms with Cyclic and Paraffin Hydrocarbons. H. I. SCHIFF AND E. W. R. STEACIE. *Can. J. Chem.*, **29** (1951) pp. 1-12.

The authors present evidence to support the belief, based on the appearance of methane as a major product, that hydrogen atoms react with hydrocarbons producing hydrocarbon radicals, and

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DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

that these radicals then undergo rapid "cracking" reactions. Reactions of H and D atoms, with benzene, cyclopropane, cyclobutane, cyclopentane, cyclohexane, propane, butane, pentane, and hexane were studied at room temperature. Gaseous reaction products, after careful purification, were flowed through a reaction tube, and the condensable products were trapped, using liquid nitrogen as cooling agent, and the noncondensable products were absorbed on silica gel. The mass spectrometer was used for analysis. D in place of H enabled the mass spectrometer results to show the amount of hydrocarbons exchanged as a result of secondary reaction of the hydrocarbon radical. Cyclopropane was the most inert of the hydrocarbons and cyclopentane was the most reactive of the cycloalkanes. Three mechanisms are suggested for the exchange of a hydrocarbon, and each of these is discussed in the light of the experimental data. The reaction $RH + H \rightarrow R + H_2$ followed by "cracking" is responsible for the products formed in the reactions.

Products: Properties, Utilization and Analysis

Autoignition of n-Hexane and n-Heptane. An Apparatus for Studying Autoignition of Engine Fuels: Results with Normal Heptane and Normal Hexane. W. J. Levedahl and F. L. Howard. *J. Research Natl. Bur. Standards*, **46** (1951) pp. 301-9.

A single-cylinder ASTM-CFR fuel-testing engine was used that had a variable compression ratio and that was modified to study the compression-ignition of homogeneous fuel-air mixtures. The fuels studied were n-hexane and n-heptane. The engine was operated on a wide range of mixtures and compression ratios. With n-heptane at a compression ratio of 7:1, the engine ran steadily for all mixtures between 0.3 and 2.5 times theoretical. The leanest mixtures did not knock, but all those richer than 0.5 theoretical knocked badly. Ionization within the cylinder was studied and typical ionization curves using n-hexane are given. Both heptane and hexane show a pronounced two-stage autoignition over a wide range of operating conditions. When residual gases are in the cylinder, the charge will burn earlier than when uncontaminated by them.

Determination of Sulfur in Petroleum Fractions by X-Ray Absorption. Samuel W. Levine and A. H. Okamato. *Analytical Chem.*, **23** (1951) pp. 699-704.

The determination of sulfur in crude oils or in petroleum fractions constitutes a significant part of the work load in the refinery analytical laboratory. Chemical methods are long and tedious and therefore expensive. X-ray absorption of sulfur is appreciably greater than that of petroleum compounds and for this reason the application of x-ray absorption to the problem of sulfur determination was studied. It was found that the accuracy of analysis was ±0.02 percent sulfur. Thirty samples can be handled by a single operator in one day. The pro-

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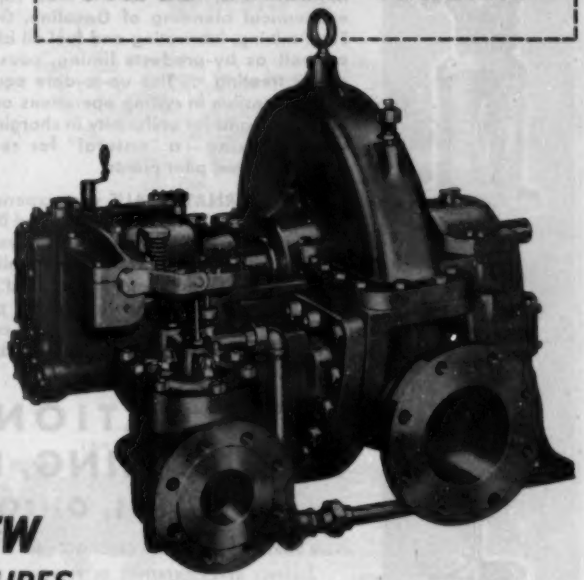

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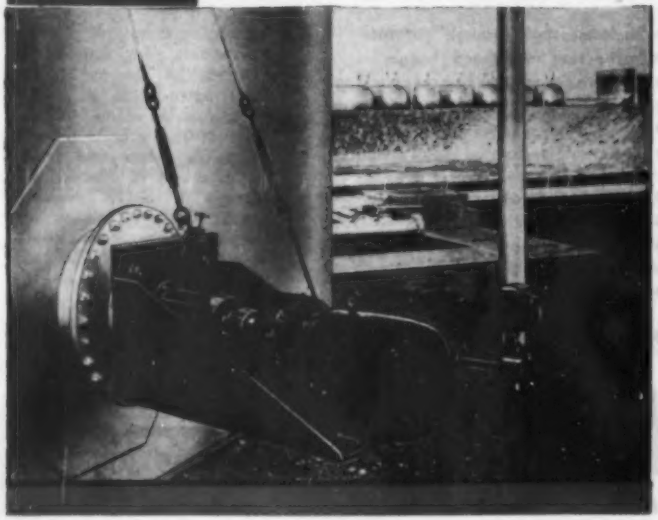

Science and Technology

cedure has the advantage of economy and non-destruction of samples. The theoretical basis of the method is presented and the equipment and operating conditions are described. A bibliography of 11 references is included.

A Simple Surface Tensiometer. N. B. COLTHUP AND R. E. TORLEY. *Analytical Chem.*, **23** (1951) pp. 804-5.

The authors developed a simple and direct method for the rapid measurement of surface tension, which is sufficiently accurate for general use and has proved useful as a rapid means of analysis where surface tension is a function of the concentrations of components to be determined. The procedure is an adaptation of the maximum bubble-pressure method. The pressure required to force air through a submerged orifice is related to the surface tension of the liquid. The apparatus used is described and typical results are given.

Carbon on Cracking Catalyst. Determination by Combustion and Conductometry. CECIL H. HALE AND MARGIE N. HALE. *Analytical Chem.*, **23** (1951) pp. 724-6.

Variation in the burning rates of the coke deposited on cracking catalysts has been observed. Carbon is entrapped during the combustion, the amount so entrapped depending upon the conditions during burning. The authors devised a procedure to follow the progress of combustion, based on the decrease in conductivity of aqueous sodium hydroxide as carbon dioxide produced by combustion is absorbed. Since the conductivity can be measured at intervals of a few seconds, the progress of the combustion can be readily followed. The method gives results for total carbon comparable to those obtained by the conventional gravimetric analysis and has also proved useful in the comparison of the burning rates of catalysts and in the selection of optimum conditions of combustion for a particular catalyst. The conductivity cell is described and the procedure is outlined. A comparison of weight percent of carbon as determined by gravimetric analysis and by conductometric analysis is presented.

Manufacture: Processes and Plant

Heat Transfer by Direct Contact Between Liquid and Vapor. R. J. O'DONNELL, R. R. BOWLES AND E. E. GULLEKSON. *Chem. Eng. Progress*, **47** (1951) pp. 309-14.

C_4 gases were cooled by direct contact with a distillate oil, using three different types of contacting equipment. The first was a downward flow empty spray tower, second a counterflow tower with disc-and-doughnut baffles and the third a perforated side-to-side baffle tray tower. The results showed that the spray tower is more effective than the disc-and-doughnut section over the entire range studied. The side-to-side baffles are more effective than either of the other sections at high vapor and low liquid rates but are approximately equal to the disc-and-doughnut baffles at low vapor and high liquid rates. The conclusion was reached that the par-

ticular arrangement studied is advantageous where the rapid cooling of a vapor under low pressure is of first importance.

Restraints on the Expansion of Vertical Tanks Under Liquid Head. PETER KERR. *Jour. Inst. of Petroleum*, 37 (1951) pp. 209-23.

Formulae were developed for the correction of tank tables for the restraining effect on expansion exerted by the tank bottom and roof, by buttstraps, and by horizontal and vertical seams. The author states that for large tanks it is fairly easy to secure accuracies of about 0.01 or 0.02 percent of the tank's capacity, at least in the undistorted parts of the tank, but that practical difficulties prevent bettering these accuracies. A correction is described as negligible if at most it can only amount to a fraction of 0.01 percent of the tank's capacity. The author concludes that it is only in preparing tank tables of high precision that the effects of the restraints considered are important. The effect of tank bottom, of buttstrap and of roof need to be taken into account, but restraint at seams appears always to be negligible.

Air-Water Contact Operations in a Packed Column. FUMITAKE YOSHIDA AND TATSUO TANAKA. *Ind. Eng. Chem.*, 43 (1951) pp. 1467-73.

The work was undertaken to study the film coefficients of mass and heat transfer in three kinds of air-water contact operations—constant temperature humidification, water cooling, and dehumidification, in columns packed with ceramic Rashig rings. It was found that the liquid-film resistance is not negligible as compared with gas-film resistance and that the same empirical equations for gas- and liquid-film coefficients can correlate the performance of a packed column throughout the three operations. The gas-film coefficients of heat and mass transfer were proportional to gas rate and to the 0.2 power of water rate, while the liquid-film coefficient was proportional to the 0.8 power of water rate. Ratio of the gas-film coefficient of heat transfer to that of mass transfer nearly equaled the humid heat of air in the column.

Isomerization and Hydrogenation Reactions in a Rectification Column. LLOYD BERG, P. R. HIPPELY AND W. S. REVEAL. *Chem. Eng. Progress*, 47 (1951) pp. 283-6.

A procedure was devised in which a portion of the packing of a rectifying column was substituted by a catalyst of a size and shape resembling column packing. Reaction takes place in the catalyst section and equilibrium between reactants and products is approached. The remainder of the column removes the lower boiling portion of the product, while the rest of the product, now no longer of equilibrium composition, is returned to the catalytic reaction section as reflux. Reactions in which the product is lower boiling than any of the reactants have been carried out. The following reactions were studied: isomerization of paraffins, using an aluminum chloride impregnated activated bauxite; isomerization of naphthenes, using the same material; hydrogenation of di-iso-

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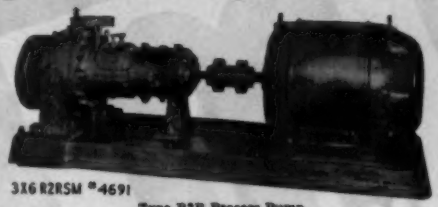

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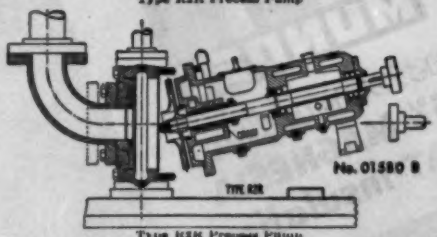

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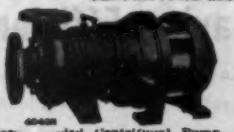

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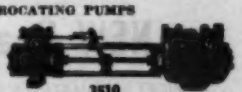

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butylene, mesityl oxide and nitropropane, using a hydrogenation catalyst. All of the reactions took place at the boiling points of the reacting materials and the runs were made under atmospheric pressure averaging 635 mm. The isomerization of the paraffins is too slow to make the procedure practical except as a research tool. The naphthenes, on the other hand, isomerize rapidly enough to permit use of the procedure in plant practice. Isooctane was obtained in high purity by hydrogenation and it appears that the process would be attractive.

Lower Acidity Sulfuric Acid Alkylation. E. C. HUGHES, D. G. STEVENS AND FRANKLIN VEATCH. *Ind. Eng. Chem.*, **43** (1951) pp. 1447-51.

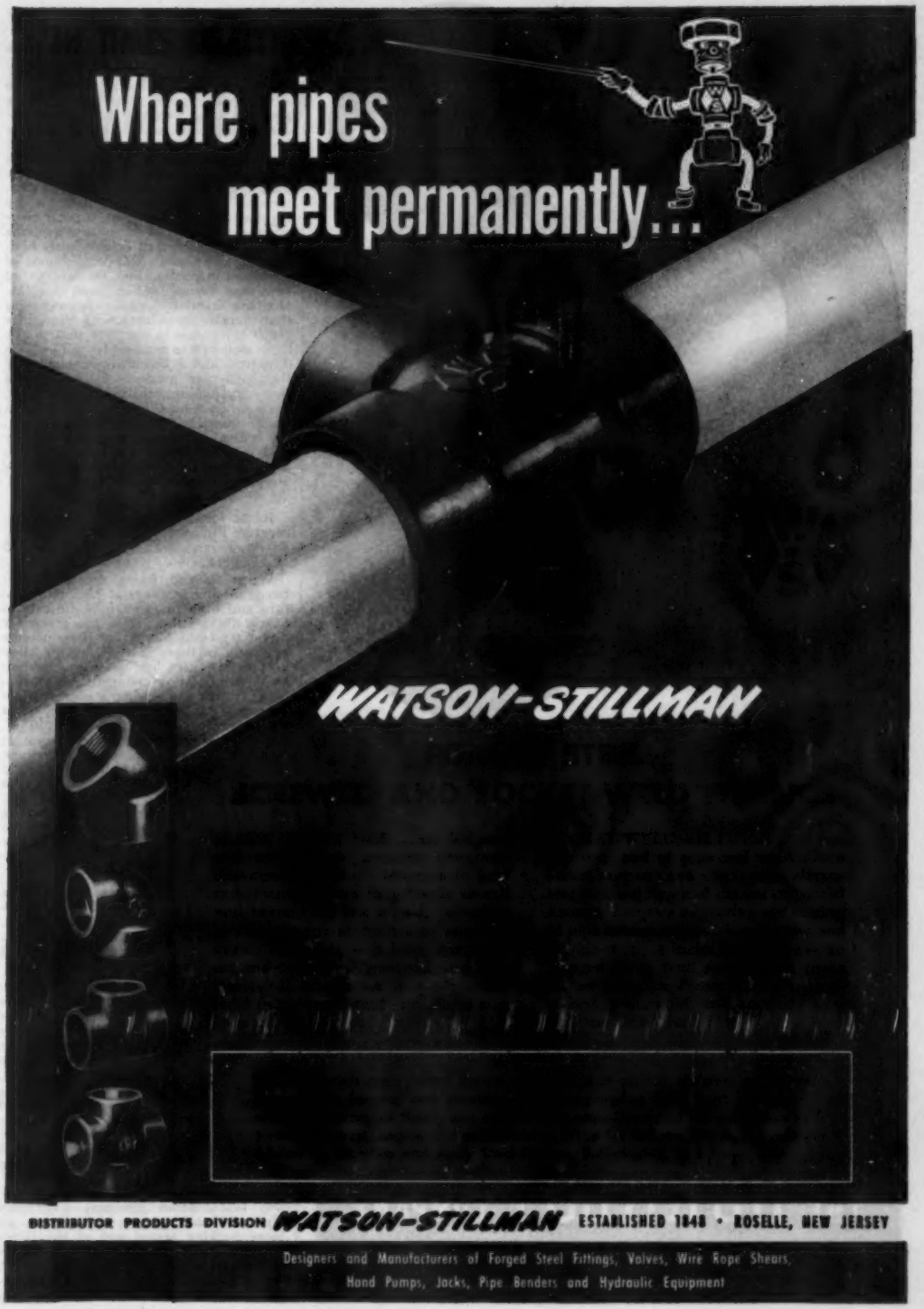
The over-all objective of the work was to make a thorough examination of the alkylation process, particularly in reference to the regions of 85 to 90 percent titratable acidity of the sulfuric acid catalyst as compared to the 90 to 98 percent acidity normally considered necessary. Preliminary observation had indicated the possibility of a substantial reduction in the amount of sulfuric acid consumed through using catalyst acid containing less than 90 percent sulfuric acid by weight. It was shown that alkylation could be successfully accomplished at 85 percent acidity with acid consumption of around 0.6 pound per gallon as compared to 1.2 pounds per gallon when a 92 percent acidity was used. Negligible changes in the yield and nature of the alkylate resulted, but there was no change in the operation of the unit as a whole other than a decreased feed of fresh acid. Because of the large amount of sulfuric acid consumed in the alkylation process and the difficulties encountered in the disposal of large quantities of spent acid, the lower reactor acidity is an important factor in the operation of an alkylation plant.

Design of Fixed-Bed Catalytic Reactors. Part II. H. B. IRVIN, R. W. OLSON AND J. M. SMITH. *Chem. Eng. Progress*, **47** (1951) pp. 287-94.

A 2-inch i.d. reactor was used in the work and temperatures were measured at various catalyst bed depths and radial positions. Sulfur dioxide and air were passed through the catalyst, which consisted of ⅛-inch alumina pellets coated with 0.2 percent platinum. The reactor was cooled by boiling water surrounding it in order to induce a large radial temperature gradient. Conversion of sulfur dioxide to sulfur trioxide was determined. Data were obtained at four mass velocities ranging from 147 to 512 pounds/(hr.) (sq. ft. of empty reactor area). Good agreement was obtained between observed temperature and conversion data using a modified Grossman method for predicting temperature and conversion in a fixed-bed reactor. The data are presented in detail in tabular and graphical form.

Asphalt-Solvent Blends. Retardation of Viscosity Rise With Time. ARNOLD J. HOIBERG. *Ind. Eng. Chem.*, **43** (1951) pp. 1419-23.

Asphalt-solvent blends are useful as paving cutbacks, waterproofings, roof coatings, dipping blacks, paints, and as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vehicles to which mineral fillers can be added to prepare protective coatings such as those used for automobile undercoatings and sound deadeners. Cutbacks are usually prepared from steam- and vacuum-reduced asphalt bases with naphtha or kerosine as solvents. The purpose of the investigation was to determine the retardation obtainable by addition of minor amounts of polar compounds to cutbacks of blown asphalts which were known to exhibit fairly high viscosity increases. Solvent dilutions of air-blown asphalts, low in content of peptizing resins, suffer from the asphaltene fraction forming aggregations that increase in volume with time. The result is increase in viscosity, that can be expressed by the relation $I = kT_a$, where T is time and k and a are constants for the particular product. It was found that alkyl amines, alcohols, and organic acids when added to such cutbacks in minor quantity had appreciable retarding effect on viscosity increase. Fatty acid amines were especially effective. Some other compounds accelerated the increase in viscosity with time.

Joints for High-Pressure High-Temperature Piping. I. H. CARLSON AND W. S. BLACK. *Trans. Am. Soc. Mech. Engrs.*, **73** (1951) pp. 237-46.

When flanged joints are made between dissimilar alloys at high temperature and high pressure it is difficult to obtain tight joints. Data are given for three ten-inch joints at 1900 pounds pressure. In these joints a ferritic alloy in a main steam line was connected to an austenitic-alloy connection to a turbine. It was found that a special pressure-seal flanged joint remained tight through 25 cycles of heating to 1050° F. and quenching with saturated steam at about 575° F. A special bellows-type flanged joint leaked 11 times out of 23 tests. However, the leakage was not large and the length of time varied from 15 seconds to 8 minutes. The joint seals itself in each instance. A spiral-wound metal asbestos-filled gasket flanged pipe joint was not found satisfactory.

Fractionating Efficiency of Various Packings in Distillation Columns Operating at Reduced Pressure. MARY MYLES, JULIAN FELDMAN, IRVING WENDER AND MILTON ORCHIN. *Ind. Eng. Chem.*, **43** (1951) pp. 1542-6.

The purpose of the work was to compare the performance of different types of packings commonly used in laboratory distillation and further, to study the effect of pressure on the efficiency of packed distillation columns. The packings studied were Berl saddles, triple- and single-turn helices, glass spheres, and a commercial Heli-grid column packing. Fractionating efficiency, throughput, and holdup were determined at various reflux ratios and at pressures from 20 to 760 mm. It was found that efficiency decreased with decreasing pressure when the pressure was below about 200 mm. The fixed Heli-grid packing was superior to all loose packing tested and of the latter packing, glass spheres gave the best results. Efficiency decreased with increasing throughput when using the Heli-grid packing, but the reverse effect was

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observed for most of the other packings. The results of the work indicate that columns filled with the loose packings studied should be operated at close to maximum throughput capacity, and that these packings may operate at the highest separating power at pressures of about 200 mm.

Fischer-Tropsch Synthesis in Slurry Phase. M. D. SCHLESINGER, J. H. CROWELL, MAX LEVA AND H. H. STORCH. *Ind. Eng. Chem.*, **43** (1951) pp. 1474-9.

The authors studied the so-called "slurry process" for the synthesis of liquid hydrocarbons from coal in which a finely divided iron catalyst suspended in oil is circulated by natural convection through a reactor in the presence of carbon monoxide and hydrogen. The paper describes the results of the operation of a pilot plant based on this procedure. The effect of operating pressure was small insofar as production of light hydrocarbons was concerned, but increase in pressure and constant space velocity gave increased synthesis-gas conversion. Increasing the operating temperature increased the formation of light hydrocarbons and the conversion of synthesis-gas. Based on carbon monoxide entering the reaction, 5 percent appeared as C_1 and C_2 hydrocarbons, 43 percent as heavier hydrocarbons of which about three-fifths boiled in the gasoline range, and 42 percent as carbon dioxide. Oxygenated compounds were obtained in the light-oil and water fractions in very large amounts. The slurry process has the advantage of improved temperature control, mass transfer, and flexibility.

Hydrocarbon Synthesis Catalyst Studies. Use of Deuterochloric Acid. H. I. WECK, S. MEYERSON AND H. S. SEELIG. *Jour. Am. Chem. Soc.*, **73** (1951) pp. 2331-3.

Promoted iron catalysts are frequently employed for the synthesis of hydrocarbons from carbon monoxide and hydrogen. To prepare the catalysts iron oxides are generally used and these are reduced, ordinarily with hydrogen, before an active catalyst is obtained. Iron catalysts that have been used in hydrocarbon synthesis studies liberate hydrogen and hydrocarbons when dissolved in hydrochloric acid. By using deuterochloric acid in place of hydrochloric acid, it was proved that the hydrocarbons are derived from iron carbide and the acid and are not adsorbed products liberated when the catalyst is dissolved. A study of the methanes formed led to the conclusion that stable iron alkyls do not exist on the catalyst. No exchange was observed between the hydrogen in a sample of n-pentane absorbed on metallic iron and the deuterium in the acid used to dissolve the iron.

Effective Thermal Conductivity of Granular Solids Through Which Gases Are Flowing. JOEL O. HOUGEN AND EDGAR L. PIRET. *Chem. Eng. Progress*, **47** (1951) pp. 295-303.

The investigation was undertaken to fulfill the need for quantitative heat-transfer data applicable to the many industrial processes in which fluids are caused to flow through granular solids. Examples are catalytic processes using solid catalysts, the combustion of gran-

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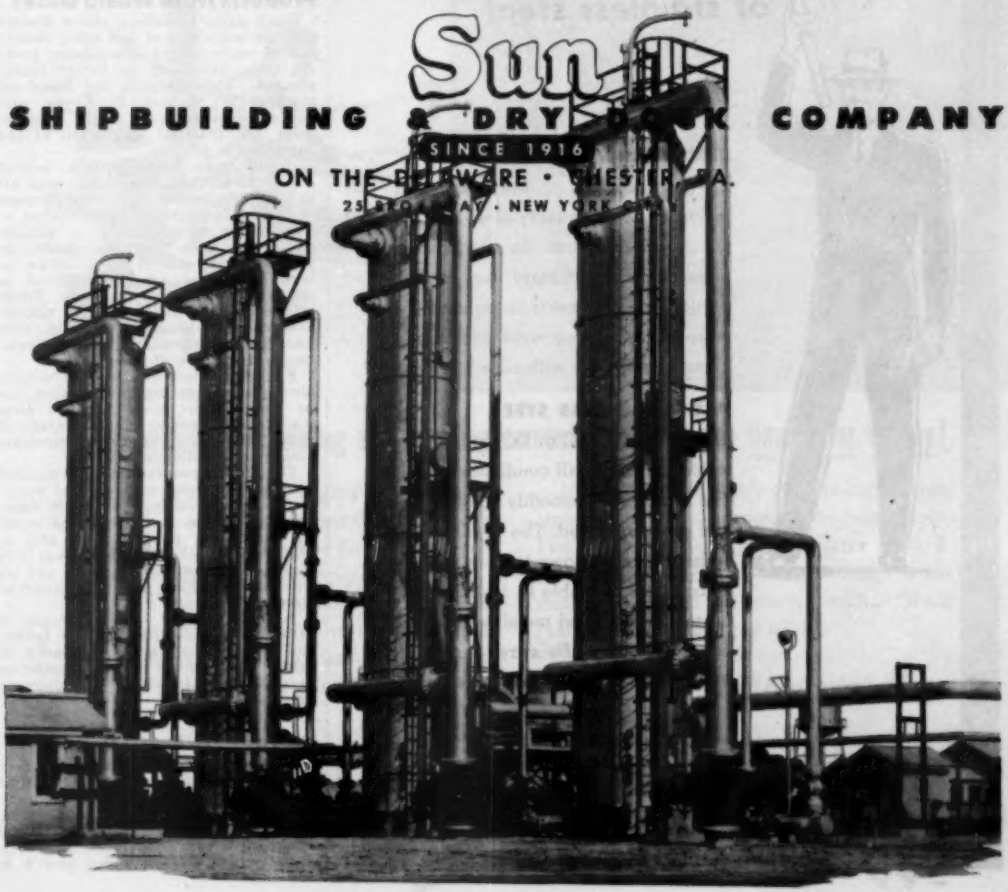

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ular materials such as coal or coke in grate furnaces, blast-furnace smelting of ores, the manufacture of producer gas, regenerative cycloheating, calcining of limestone, etc. Air was cooled by drawing it downwardly through radially cooled beds of granular solids and the data were analyzed by means of the classical equations for unsteady transfer of heat by conduction. The results were interpreted as effective thermal conductivities of the granular beds. The solids studied included five sizes of Celite cylinders, and two sizes of spherical Celite pellets. A 50-fold range of mass velocity, from 75 to 3700 pounds per square foot per hour was covered and air temperatures were varied from 75 to 800° F. A generalized equation for thermal conductivity is given. Conductivities of the air-Celite systems varied from 0.30 to 2.30 Btu. per hour per square foot per °F. These values are 20 to 100 times that of the fluid in a static state and from 2 to 15 times as great as the solid itself.

New Infilco Process Yields Products from Waste Gases

Stack gases containing sulfur dioxide produce sulfuric acid and other chemicals in an improved autoxidation process being developed by Infilco Incorporated. The processes are based on research by Harmon E. Keyes, who has spent many years in the development and practical application of the autoxidation process.

In the autoxidation process, sulfur dioxide is brought into contact with air in a solution containing a small amount of iron or manganese as a catalyst to form either ferric sulfate or sulfuric acid. The same plant equipment can produce either acid or ferric sulfate, or both. The acid can be produced in strengths of 25 percent or more. Ferric sulfate can be produced at any reasonable concentration of free acid, thus providing requisite acidity in coagulation where pH control is vital.

Equipment for the process, which also aids in reducing air pollution, can be designed to handle hot and dirty stack gas to remove the percentage of sulfur dioxide necessary to eliminate atmospheric pollution.

The Infilco program is an integrated plan, and includes methods and equipment for specific installations in refineries, as well as in smelters and roasting plants, for producing the acid or other sulfate chemical from various sources of sulfur dioxide gases, and for concentrating dilute acid to commercial strength.

Keyes, developer of the process, is acting as special consultant to Infilco, and will devote himself primarily to further development of the autoxidation process, a field in which he holds many patents.

48 Tankers Being Built

Oil tankers under construction and/or under contract throughout the world as of July 1 totaled 48, according to American Bureau of Shipping. Of the total, 22 were in the U. S., 13 in the United Kingdom, 1 each in Belgium and Italy, 5 in Germany, 2 in Japan and 4 in Holland.

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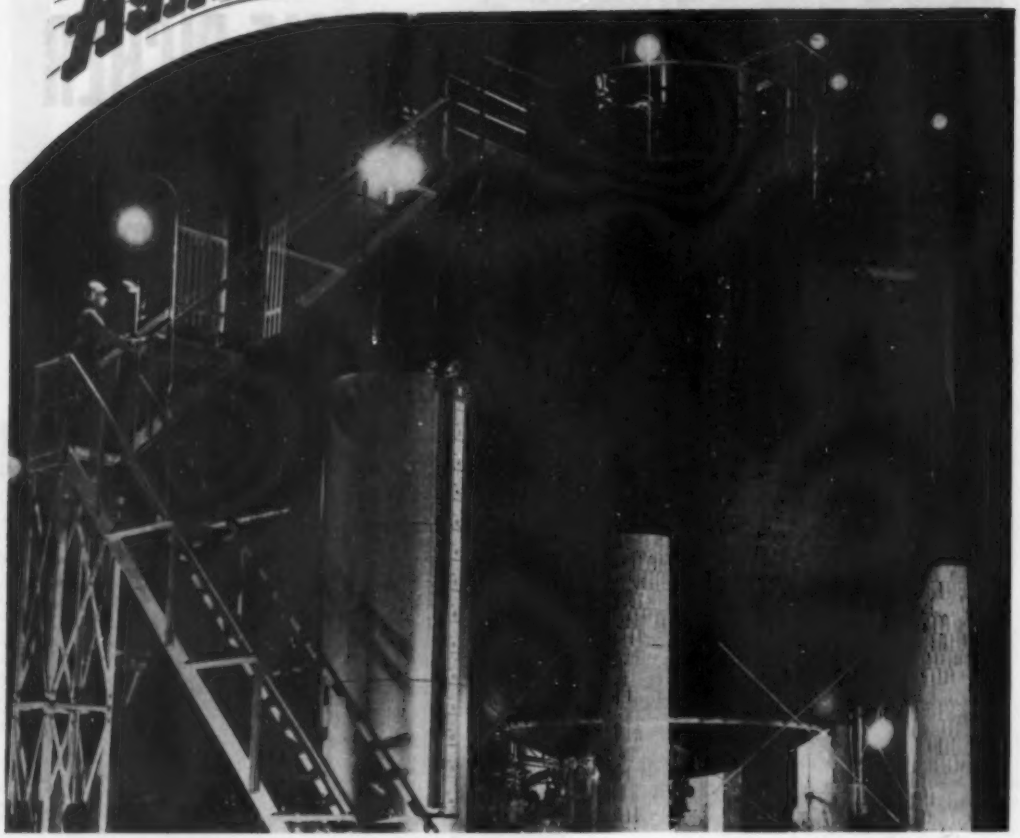

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Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by DR. HEINZ HEINEMANN

(From the Official Gazette, May 15, 22, 29 and June 5, 12, 1951)

REFINING

U.S.P. 2,552,528-34. Process for Breaking Petroleum Emulsions. M. DeGroote to Petrolite Corporation, Ltd.

Petroleum emulsions of the water-in-oil type are broken by a demulsifier including high molal oxypropylation derivatives of monomeric polyhydric compounds, or the like. The various patents cover the use as demulsifiers of special types of such compounds.

U.S.P. 2,552,564. Separation of Organic Comopunds. C. C. King and N. L. Dickinson to The M. W. Kellogg Company.

A mixture of hydrocarbons and water-insoluble oxygenated organic compounds, as for example obtained as the non-aqueous product of a Fischer-Tropsch synthesis, is treated with an aqueous solution of an oxygen-containing solvent for the oxygenated compounds and with a relatively low-boiling hydrocarbon wash-oil in an extraction zone. The raffinate phase formed comprises hydrocarbons while the aqueous extract phase comprises oxygenated compounds, which are thus separated.

U.S.P. 2,552,669. Process for Purifying Normal 1-Olefins. H. A. Dutcher to Phillips Petroleum Company.

A mixture of C_4 or C_5 hydrocarbons containing a corresponding secondary base 1-olefin, such as butene-1 or pentene-1, is treated to remove therefrom a narrow boiling fraction comprising the 1-olefin and isobutylene or 2-methyl-1-butene, respectively. This narrow boiling fraction is treated with nitrosyl chloride in the presence of 1-2 percent of water (calculated on the weight of said fraction) at a temperature of 0-100° F., and in the liquid phase. The secondary base 1-olefin is recovered from the reaction mixture.

U.S.P. 2,552,692. Extraction of Isobutylene by Polymerization and Depolymerization. W. A. Schulze and J. E. Mahan to Phillips Petroleum Company.

A gaseous C_4 hydrocarbon stream containing isobutylene is contacted under polymerization conditions with a silica gel catalyst promoted by a minor incorporated amount of an oxide of a metal of group III-B or IV-A of the periodic system. The isobutylene polymer formed is separated from the other reaction products and contacted under depolymerizing conditions in the presence of steam with the spent polymerization catalyst. Depolymerized isobutylene is recovered.

U.S.P. 2,553,183. Fuel Oil Composition. J. B. R. Caron, C. Wies and E. B. Glendenning to Shell Development Company.

Fuel oil containing entrained moisture or cracked components is compounded with 0.0025-0.005 percent of a certain type of amino alkyl glyoxalidines, such as 1-aminoethyl-2-heptadecenyl glyoxalidine. The additive prevents clogging of the fuel oil.

U.S.P. 2,553,441. Stabilization of Organic Materials. J. A. Chenicek to Universal Oil Products Company.

Organic materials, such as cracked gasoline, are stabilized against oxidative deterioration by the addition of a disubstituted aminomethyl-dihydroxybenzene, such as dialkylaminomethyl-4-alkoxyphenol.

U.S.P. 2,553,469. Method for Fractional Distillation. J. A. Pellettere to Gulf Oil Corporation.

Details are claimed of a continuous process of fractional distillation, e.g. for the separation of a mixture of C_3 and C_4 hydrocarbons.

U.S.P. 2,553,624. Depolarization Process for Petroleum Fractions. C. C. Allen to Anderson-Prichard Oil Corporation.

A petroleum distillate fraction is contacted with strong H_2SO_4 in at least three stages. In-stream samples following the third and each succeeding stage are tested, and the acid contacting is continued until the tested fraction is found to be free of polar organic substances, as evidenced by low dry-point, no sludging coloration with concentrated H_3PO_4, high stability to actinic action, absence of mineral spirits odor and kerosene smell. The inorganic contaminants are then removed by aqueous caustic scrubbing and by contact with absorbent clay. Aromatic-free depolarized naphtha is obtained.

U.S.P. 2,554,667. Process for Breaking Petroleum Emulsions. M. DeGroote to Petrolite Corporation, Ltd.

Details are claimed of a process for breaking petroleum emulsions of the water-in-oil type by means of a demulsifier including high molal oxypropylation derivatives of monomeric polyhydric compounds, e.g. of polypentaerythritols.

U.S.P. 2,554,687. Stabilization of Organic Compounds. R. B. Thompson and J. A. Chenicek to Universal Oil Products Company.

Motor fuel is stabilized against deterioration in storage by the addition of a small amount of a 5-hydroxy-2,3,6,9-tetrahydronaphtho-(1,2-b)-furan, or a similar tricyclic compound.

U.S.P. 2,554,908. Separation of Hydrocarbons by Selective Adsorption. A. E. Hirschler to Sun Oil Company.

An olefin is separated from a non-aromatic hydrocarbon charge by means of an olefin-selective adsorbent, such as silica gel, in such a manner that polymerization of the olefins is minimized.

U.S.P. 2,555,509. Stabilization of Organic Compounds. R. H. Rosenwald to Universal Oil Products Company.

A motor fuel, cracked gasoline, or styrene material contains a small percentage of a hydrocarbon dinitroso compound in which the N atoms are attached to adjacent C atoms, e.g. a dinitrosobenzene of this type. The additive inhibits deterioration by oxidation.

U.S.P. 2,555,650. Azeotropic Distillation of Hydrocarbons. G. R. Lake to Union Oil Company of California.

A mixture of heptane and methylcyclohexane is azeotropically distilled in the presence of a sufficient amount of dioxolane to vaporize the heptane together with the dioxolane. Methyl cyclohexane is obtained as the residue.

U.S.P. 2,555,939. Distillation of Styrene from Polymers. D. S. Sherwin to Phillips Petroleum Company.

Details are claimed of a method for separating styrene from its mixture with styrene polymer by repeated fractionation.

U.S.P. 2,555940. Separation and Purification of Unsaturated Hydrocarbons. R. K. Simms to Phillips Petroleum Company.

A mono-olefin rich hydrocarbon fraction containing impurities of conjugated diolefins is refined by contacting it with popcorn polymer to remove said impurities.

U.S.P. 2,556,030. Process for Distilling Vinyl Aromatic Compounds. K. E. Coulter and H. G. Hornbacher to The Dow Chemical Company.

A mixture of ethylvinylbenzene and divinylbenzene is recovered from a more complex mixture obtained by pyrolysis of diethylbenzene by repeated distillation, first in the presence of steam and with the addition of a polymerization

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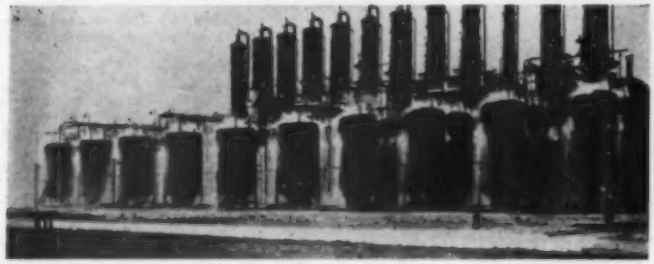

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inhibitor. Details of the process are claimed. The method can also be employed for purifying ethylvinylbenzene contained in a mixture with higher boiling ingredients.

U.S.P. 2,556,269. Conversion of Salts in Petroleum Oils. G. R. Gilbert to Standard Oil Development Company.

Hydrocarbon oil containing inorganic salts is treated at a temperature above 160° F. with oil-soluble mahogany acids of a molecular weight greater than 325 to reduce or eliminate the salt content of the oil.

U.S.P. 2,556,644. Thermal Defluorination of Alkylated Aromatic Hydrocarbon Mixtures. L. F. Brooke, J. B. Cull, and B. E. Berlenbach to California Research Corporation.

Organic fluorine compounds present in a mixture with benzene, alkyl benzenes and free HF, such as normally occurs in the oil phase of a product obtained by alkylating benzene with propylene polymers in the presence of a HF catalyst, are defluorinated with formation of HF by heating the mixture at 425-550° F. under a pressure between atmospheric and 20 psi.

U.S.P. 2,557,019. Motor Fuel and Antiknock Agent. W. E. Morris and W. C. Howell, Jr., to Standard Oil Development Company.

A motor fuel comprises hydrocarbons of the motor fuel range, an alkyl lead antiknock compound, a scavenging agent and an alkyl thiophene boiling above 325° F.

CRACKING AND REFORMING

U.S.P. 2,552,573. Hydrocarbon Conversion. G. A. Mills to Houdry Process Corporation.

In cyclic cracking operations consisting of a regeneration and a cracking period, this cracking period comprises a first stage where fluent solid catalyst contacts substantially only hydrocarbons and a second stage in which it contacts hydrocarbons and substantial amounts of steam. According to the invention the cracking catalyst is protected against the deleterious effect of deactivation by steam at elevated temperatures by maintaining a substantial amount of coke on the catalyst during said second cracking stage. Details are claimed.

U.S.P. 2,554,413. Apparatus for Catalytic Cracking of Hydrocarbons. H. C. Kuhn to Sinclair Refining Company.

The construction is claimed of a catalytic cracking reaction vessel which prevents irregularities of catalyst flow by the use of specially arranged apertured collector baffles.

U.S.P. 2,555,129. Catalyst Control Slide Valve. W. A. Hagerbaumer to Socony-Vacuum Oil Company, Inc.

In a continuous catalytic cracking system of hydrocarbons in which a particle-form contact material is gravitated downwardly as a continuous column through a reaction vessel, where this material is contacted with hydrocarbons at reaction conditions, and is then gravitated downwardly through a regeneration vessel, closure means of special con-

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ISOMERIZATION

U.S.P. 2,554,202. Isomerization of C⁵ Olefins with Boron Ortho Phosphate Catalyst. D. McNeil and P. W. Reynolds to Imperial Chemical Industries, Ltd.

A normal alkene with 4-8 C atoms is contacted in the gaseous state at a temperature of 350-600°C. with a BPO_4 catalyst. Branched chain alkenes, such as isopentene, are obtained.

U.S.P. 2,554,251. Isomerization of 2,4,4-Trimethylpentene-2. B. E. Hudson, Jr., to Standard Oil Development Company.

A mono-olefinic hydrocarbon having a neopentyl structure and containing alkyl substituents, such as 2,4,4-trimethyl pentene-2, is contacted in the liquid phase with H_2SO_4 at a temperature of 0-150°C. The double bond is shifted from the 2-position to the 1-position with no change in the position of the alkyl substituents.

U.S.P. 2,554,425. Liquid Level Control. J. E. Storment to Phillips Petroleum Company.

An apparatus and a method are claimed for controlling the liquid level of liquid being evaporated in an evaporator at a desired level. The method is useful, for example, in the mixed phase isomerization of normal butane in the presence of an aluminum halide catalyst.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,552,659. Catalyst Regeneration Process. J. G. Allen to Phillips Petroleum Company.

Spent finely divided hydrocarbon conversion catalyst is mixed with a liquid to form a slurry. This slurry is injected directly into and through the point of combustion of fuel in a combustion zone wherein the carbonaceous deposits are rapidly removed from the catalyst by dislodgment and rapid combustion for a short time at a temperature of 2000-3500° F.

U.S.P. 2,553,239. Process for the Production of Selectively Acting Bleaching Powders, Catalysts, and Related Products on the Basis of Clays Capable of Activation. A. Christiansen.

A de-colorizing earth of the montmorillonite type is activated and improved as to its adsorptive properties by treating the earth with dilute mineral acid to remove only a portion of the bases present. After washing for removal of the acid, the earth is pre-dried at a temperature not substantially greater than 220° F. Remaining water is removed by extraction with a volatile water solvent of high strength, such as alcohol or acetone. The solvent is then removed at a temperature not substantially in excess of 220° F. A product of high porosity and large surface is obtained, useful as cracking catalyst and for bleaching mineral oils and the like.

U.S.P. 2,553,402. Titania Gels and Method for Their Manufacture. G. C. Connolly and R. E. Schexnailder, Jr., to Standard Oil Development Company.

Titania gel is precipitated from a solution of titanyl sulfate by ammonium hydroxide, or the like, in an amount to impart to the supernatant liquid over the gel an excess alkalinity of .01-.10 normal. The gel is washed until incipient peptization sets in, and is then heated over the b.p. of water and dried. Gels of high purity useful as adsorbents, catalysts and catalyst carriers are obtained.

U.S.P. 2,553,551. Oxidation Carrier for the Oxidation of Hydrocarbons. E. S. Corner and C. S. Lynch to Standard Oil Development Company.

A mixture of equal parts of Fe_2O_3 and MnO_2 is used as an oxygen carrier for the oxidation of normally gaseous hydrocarbons, e.g. for the formation of industrial gases containing CO and H_2.

U.S.P. 2,554,426. Spent Catalyst Stripper for Fluidized Catalytic Cracking Process. E. Strunk and L. H. Vautrin to Phillips Petroleum Company.

The construction is claimed of an apparatus for stripping volatile material adsorbed on or associated with solid contact particles.

U.S.P. 2,555,282. Production of Microspheroidal Gel Catalyst by Spray Drying. K. D. Ashley to American Cyanamid Company.

A hydrous gel composed of a major proportion of hydrated silica and a minor quantity of hydrated alumina, hydrated magnesia, or a mixture of these two is ground. A 4-10 percent aqueous suspension of the ground gel is dispersed into a current of hot gases having an inlet temperature of 600-1000° F. It is suspended in these gases while the free water of the suspension is evaporated and the gel particles are dried to less than 20 percent water content. A catalyst in the form of regular spheroids of predetermined particle size is obtained.

U.S.P. 2,556,280. Process and Catalyst for Reforming Hydrocarbons. K. K. Kearby to Standard Oil Development Company.

A catalyst useful in reforming naphthas and aromatizing aliphatic hydrocarbons consists of at least 85 percent of zinc aluminate spinel support, up to 15 percent of molybdenum oxide, and a small activating amount of CaO or MgO.

ALKYLATION

U.S.P. 2,552,980. Alkylation of Olefinic Compounds. E. C. Ladd and L. Y. Kiley to United States Rubber Company.

An olefin is heated in the presence of a peroxide catalyst with an alpha-tert.-alkanal of the formula $(R_1)(R_2)(R_3)C\text{-}CHO$ where R_1 is a lower alkyl group, and R_2 and R_3, each, are methyl or ethyl. An alkylated compound is formed with elimination of CO. Thus, 1-octene can, for example, be alkylated with neopentenal. A new dodecane is formed.

U.S.P. 2,554,275. Combination Alkylation and Polymerization Process. W. M. Smith to Standard Oil Development Company.

Normally gaseous olefins are alkylated. The alkylation effluent is used as a diluent in the polymerization of the gaseous olefin. The alkylation and the polymerization product are thus combined and saturated hydrocarbons boiling in the gasoline range are obtained.

DESULFURIZATION

U.S.P. 2,556,157. Desulfurization Process. K. M. Brown and C. G. Gerhold to Universal Oil Products Company.

Hydrocarbon oil containing mercaptans is treated with an aqueous alkali solution and an organic solvent, e.g. methanol. The aqueous solution is separated from the oil and distilled to vaporize mercaptans and organic solvent. A mercaptan fraction is obtained by condensation. The remaining aqueous solvent fraction is further treated to recover small further amounts of mercaptans.

U.S.P. 2,556,414. Separating Mercaptans. J. A. Brooks, J. H. Krause, T. B. Tom and N. Fragen to Standard Oil Company (Indiana).

Sour petroleum distillate boiling higher than gasoline is freed from mercaptans by extracting them with a solution containing 50-65 parts by weight of KOH, 50-35 parts of water, and 15-75 volumes of methanol per 100 volumes of aqueous KOH. The resulting extract is diluted with water to effect separation into two phases, an aqueous KOH-methanol phase and an oily mercaptide phase.

U.S.P. 2,556,438. Mercaptan Extraction System. H. A. Parker and G. W. Ritter to Standard Oil Company. (Indiana.)

Details are claimed of a process for removing high boiling mercaptans from a hydrocarbon distillate boiling between 325-650° F. by extraction with a solvent mixture of aqueous KOH and methanol cresylate in special proportions and further treatment.

U.S.P. 2,556,836. Method of Treating Sour Petroleum Distillates. J. G. Browder and A. R. Smith to Standard Oil Development Company.

A sour petroleum distillate containing mercaptans and boiling below 750° F. is mixed with not more than 1 percent by volume of an aliphatic alcohol. The mixture is contacted with a catalytic amount of not more than 5 percent by volume of an alkali metal hydroxide solution while adding a mild oxidizing agent, e.g., air. A sweetened distillate of unimpaired color is obtained.

U.S.P. 2,556,837. Sweetening of Petroleum Distillates. J. G. Browder and A. R. Smith to Standard Oil Development Company.

The process of this patent is closely related to that of U.S.P. 2,556,836. An amide is here used as the catalyst in addition to an alkali metal hydroxide solution.

HEAVY OILS AND WAXES

U.S.P. 2,552,570. Oxidation Resisting Hydrocarbon Products. J. G. McNab, N. V. Hakala and J. P. McDermott to

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Up from Lake Charles...with Cities Service!

For the past decade, during Cities Service's wide and rapid expansion of its petroleum processing facilities, Kellogg has worked closely with this refiner in the design and construction of several vast undertakings.

First job was a mammoth refinery at Lake Charles, Louisiana. The first complete modern refinery to be built from the ground up, it included three catalytic crackers...and alkylation, deasphalting and crude topping units as well as all plant-site facilities. Concurrently, a butadiene plant was built on an adjacent site.

Immediately following World War II, Kellogg undertook the complete modernization of the Cities Service East Chicago 35,000 BPD refinery . . . engineering and constructing new Fluid catalytic cracking, delayed coking and light ends fractionating units as well as revamping other facilities.

Today sees Kellogg at Ponca City for Cities Service. It is another major modernization job with Fluid catalytic cracking as the principal new process.

THE M. W. KELLOGG COMPANY

A SUBSIDIARY OF PULLMAN INCORPORATED

for fifty years an integral part of processing history

NEW YORK · JERSEY CITY · LOS ANGELES · TULSA · HOUSTON · TORONTO · LONDON · PARIS

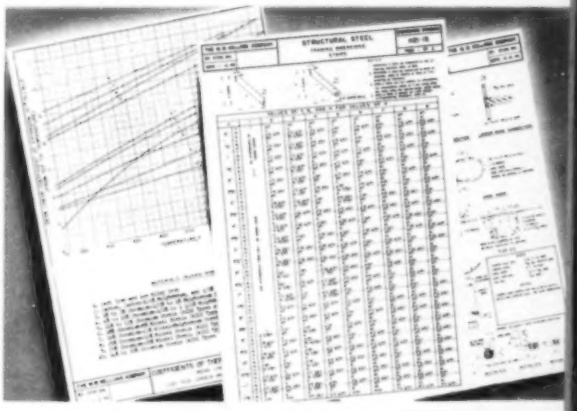
Portrait at

This year is Kellogg's fiftieth of service to industry. At this time naturally, as a group of men—known collectively to the modern business world as The M. W. Kellogg Company—we can think back nostalgically. We can remember the chimney stacks

"Firm Foundation for Every Task"

Camera "portraits" of M. W. Kellogg today, appearing in preceding issues of this publication, have reviewed the research, development, process design and design engineering phases of the Kellogg operation.

This month, the camera looks at the vital task of collecting, evaluating and disseminating Technical Data and Standards . . . and then indicates how this basic work influences Procurement practice and efficiency.



1. ***THE PRACTICE OF ENGINEERING*** is similar to most professional operations . . . highly individual in its approach to problems. But unless *the best* of each engineer's approach is captured for the benefit of others, much individual effort would be repeated on the same problems. Thus, at Kellogg there is a special *Standards Group*—engineers, whose sole function is to record the best methods for solving many problems.

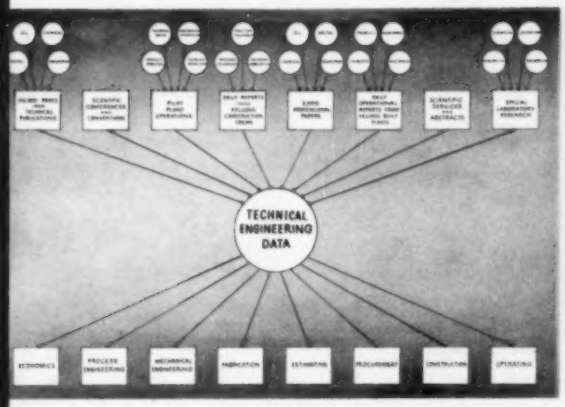
4. ***CONSTANT CHECKING*** and re-checking of design specifications is the responsibility of all Kellogg engineers who regularly visit operating units. Such visits are scheduled when possible for turn-around periods so that the company's engineers can inspect process equipment and personally observe how Kellogg design stands up in actual practice.

5. ***DESIGN STANDARDS*** and detailed specifications are obviously most important in the design function of the company. But they also contribute greatly to the efficiency of such a major function as *Procurement*. Kellogg's procurement force is a large one, issuing more than 60,000 purchase orders a year, on the average. The availability of detailed specs on all items regularly purchased speeds the procurement job measurably.

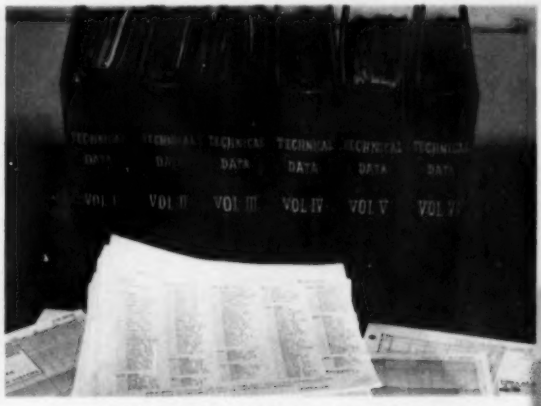
Fifty... no 7

M KELLOGG W
1901-1951
50th Anniversary

we built in 1901 . . . the first crude vessels for oil refiners in the 'teens . . . our first combination unit. The forty-odd Fluid cat crackers built in these years. But, after all, The M. W. Kellogg Company is only a factor as it is able to serve industry today. For that reason, we are presenting this series of monthly camera studies which document our belief that a truly integrated organization can better serve industry to achieve greater earning power. This is No. 7 in the series.

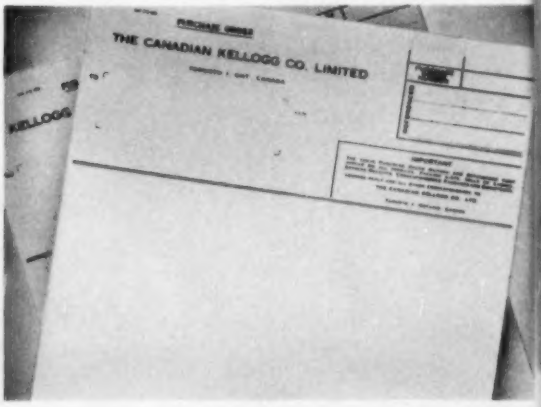


2. *THESE BEST METHODS* are then made available to the entire engineering organization in the form of "Standards." Kellogg design standards, of course, embrace recognized codes, but they also project and amplify the codes for more efficient engineering and operation. Another group of engineers, with a supporting staff, specialize exclusively in the gathering, evaluation and dissemination of *Technical Data*.



3. *THIS SIX-VOLUME SET* is literally priceless. While it includes much information that is available to the entire engineering fraternity, it also includes much more that is exclusive. It contains Kellogg's own research and development data, *plus* the summarized analyses of operating data from the more than 450 process units designed by the company during modern processing history.

6. *ORGANIZATION OF THE PROCUREMENT GROUP* closely parallels that of the Engineering Departments. Buyers specialize in specific phases such as vessels, equipment, instruments, etc., and in classes of materials and services. Thus, each specialized buyer has the direct support of the technical knowledge of the *matching* engineering group.

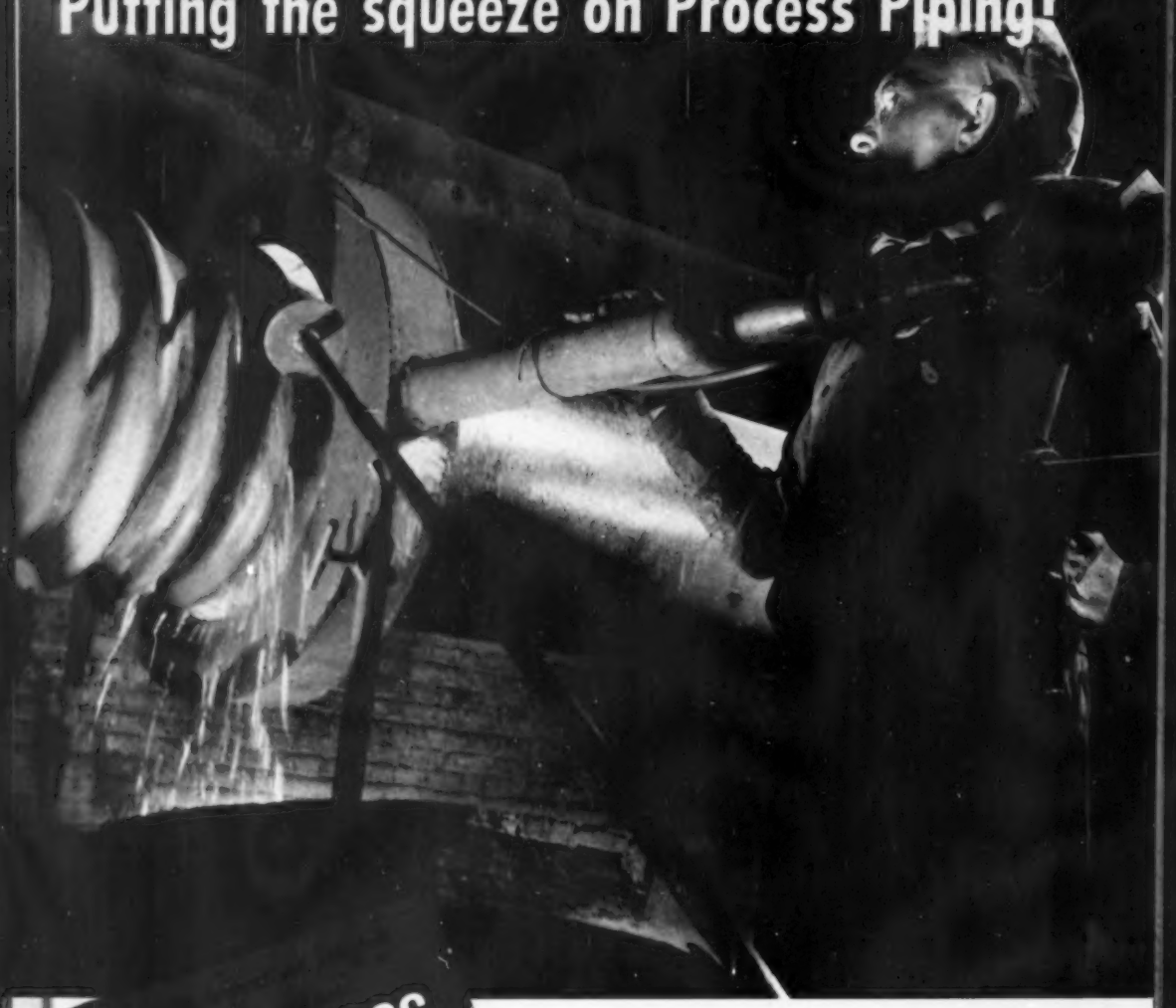


7. *KELLOGG PURCHASING SPECIALISTS*, because of their close integration within a complete engineering-fabricating-contracting organization, are in an advantageous position to weigh delivery dates against price. Correct decisions between these factors are particularly important when they govern the starting date of plant *earning power*. Worldwide facilities also speed procurement and consequently project completion dates.

NEXT MONTH

. . . in the eighth in this series of camera studies of M. W. Kellogg today . . . you will see how Kellogg's original bent for manufacturing serves the company today in meeting engineers' toughest "specs".

Putting the squeeze on Process Piping!



M. W. KELLOGG

This special machine put the squeeze on the first 30"O.D., chrome-moly piping to be successfully corrugated. The Kellogg technique of incremental heating and working employed in this operation has many other advantageous applications in fabrication of refinery equipment.

Special Studies of unusual problems such as stress corrosion and graphitization to assure long life and low maintenance.

Exclusive Equipment for accurately analyzing stresses in piping and providing unique data for critical installations.

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Vacuum Vessels
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Process Piping
Hi-pressure—Hi-temp Power Piping
Bends and Headers
Giant One-Piece Bends
Forged and Welded Fittings
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Metallurgical Research by recognized specialists who have made major contributions in this field.

Complete Facilities for the fabrication of steel products from simple forgings to specially cast bimetallic devices.

Rigid Quality Control, devised by specialists, including chemical and micro analyses as well as mechanical and non-destructive testing.

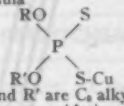
NEWS FOR OPERATORS IN WESTERN CANADA!

Canadian Kellogg Company has established complete shop facilities for the fabrication of all types of piping at EDMONTON in Alberta Province. Inquire directly or through any Kellogg office.

The M. W. Kellogg Company *(A Subsidiary of Pullman Incorporated)* **New York, Jersey City, Los Angeles, Tulsa, Houston, Toronto, London, Paris**

Standard Oil Development Company.

A hydrocarbon oil contains 0.02-3 percent of a composition of the approximate formula



where R and R' are C_8 alkyl groups. The additive imparts oxidation resisting properties to the oil, e.g., a mineral lubricating oil.

U.S.P. 2,552,913. Soluble Oil. S. P. Waugh to Tide Water Associated Oil Company.

A mineral oil is incorporated with 5-50 percent (based on the weight of the whole composition) of a S-, P-, and Cl-containing extreme pressure agent, a water-soluble soap as emulsifier, a certain amount of water, 0.3-3 percent of a polyhydroxy alcohol and 1-5 times that much of an alcohol-ether. A stable soluble oil composition is obtained.

U.S.P. 2,553,422. Sulfonate Grease. R. O'Halloran to Standard Oil Development Company.

A grease is formed from a lubricating oil and 10-30 percent by weight of a complex addition product of an oil soluble alkaline earth metal petroleum sulfonate and a similar salt of a carboxylic acid of low mol weight. The complex addition product is formed from 28-55 percent of the acid salt and 45-72 percent of the sulfonate. This grease shows increased oxidation resistance.

U.S.P. 2,553,423. Lubricating Grease Composition. W. W. Shepard to Standard Oil Development Company.

The product of this patent is closely related to that of U.S.P. 2,553,422. A metal salt of a mixture of about equal parts of at least two sulfonic acids with mol weights of 350-380 and 420-500, respectively, is here employed instead of the alkaline earth metal petroleum sulfonate.

U.S.P. 2,553,588. Mineral Oil Lubricant Containing Alkyl Ketone-P_2S_5 Reaction Product. E. C. Hughes to The Standard Oil Company (Ohio.)

A mineral oil lubricant contains a minor amount of the reaction product of an alkyl ketone having at least 12 C atoms, such as dipalmityl ketone, with 0.1-2.0 moles of P_2S_5 per mole of the ketone obtained at a temperature of about 500° F. The oil-dispersible additive improves the stability of the lubricant against oxidation.

U.S.P. 2,554,222. Lubricants. F. H. Stross to Shell Development Company.

A major amount of a liquid petroleum lubricant is compounded with a silica aerogel in an amount at least sufficient to impart a gelled structure to the composition, and with 1-25 percent by weight of the aerogel of a hydrophobic cationic surface-active agent, such as N-cetyl piperidine. The gelled lubricant has improved stability against water.

U.S.P. 2,554,244. Improving Stability of Waxes. S. H. Dole to Standard Oil Development Company.

Waxy constituents are separated from crude oils containing them in such a manner that they contain less than 10 percent of oil. They are then passed over bauxite at a temperature of 600-700° F. The separated waxes are then contacted with bauxite at a temperature of 140-200° F. Refined waxes of high heat and light stability are obtained.

U.S.P. 2,554,282. Lubricating Oil Manufacture. A. Voorhies, Jr., to Standard Oil Development Company.

A lubricating oil is upgraded by subjecting it to the influence of hydrogen and mild hydrogenation conditions of temperature and pressure in the presence of a catalyst consisting of a mixture of two mols Ni_2S_3 and one mol WS_2. The viscosity index of the oil is improved.

U.S.P. 2,554,395. Lubricant Manufacture. W. N. Axe to Phillips Petroleum Company.

Details are claimed for the manufacture of a lubricating oil from an extract oil including most of the naphthenes, aromatics, and asphalts obtained by the solvent-refining of a mineral oil stock.

U.S.P. 2,555,104. Aluminum Soap Compositions and Greases Containing Them. K. D. Ashley and S. Mason to American Cyanamid Company.

A grease composition comprises a major proportion of a hydrocarbon lubricating oil and 1-20 percent by weight of the aluminum salt of a mixture of 1-20 percent of dimerized polyunsaturated fatty acids of 18 C atoms and 99-80 percent of monomeric saturated fatty acid of 12-22 C atoms.

Patents

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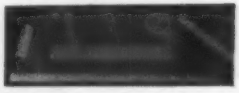
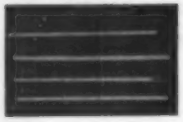
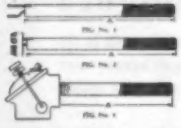


TUBES



THERMOCOUPLES



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ALTON, ILLINOIS, U. S. A.

PETROCHEMICALS

U.S.P. 2,552,591. Aromatic Acid Synthesis. W. H. C. Rueggeberg, R. K. Frantz, and A. Ginsburg.

An aromatic hydrocarbon, e.g., benzene, is reacted under water-free and CS_2-free conditionswith $AlCl_3$ and liquid phosgene in the absence of any other solvent. The reaction product is hydrolyzed. The corresponding aromatic acid, e.g., benzoic acid, is obtained.

U.S.P. 2,552,670. Purification of Cyclic Ketones Obtained by Oxidation of Hydrocarbons. H. W. Fleming to Phillips Petroleum Company.

Cyclic ketones are obtained substantially free from organic peroxide impurities by partial oxidation of the corresponding cycloparaffin, e.g., cyclopentane, with oxygen in the presence of an oxidation catalyst. Details for further treating the reaction products are claimed.

U.S.P. 2,552,769. Octylthiophene Preparation. P. D. Caesar to Socony-Vacuum Oil Company, Inc.

A mixture of a thiophene having at least one replaceable nuclear hydrogen and diisobutylene is contacted under alkylation conditions with a Friedel-Crafts metal halide catalyst. Octylthiophenes are produced.

U.S.P. 2,552,796. Thiophene-Sulfur Monochloride Synthetic Resins. E. Koft, Jr., to Socony-Vacuum Oil Company, Inc.

Thiophene or a monoalkyl thiophene is reacted with sulfur monochloride in a molar ratio corresponding to not more than two moles of the thiophene compound for each mole of the sulfur chloride. Synthetic resins are obtained.

U.S.P. 2,552,978. Method for Preparing Thiophene Carboxylic Acids. K. L. Kreuz to The Texas Company.

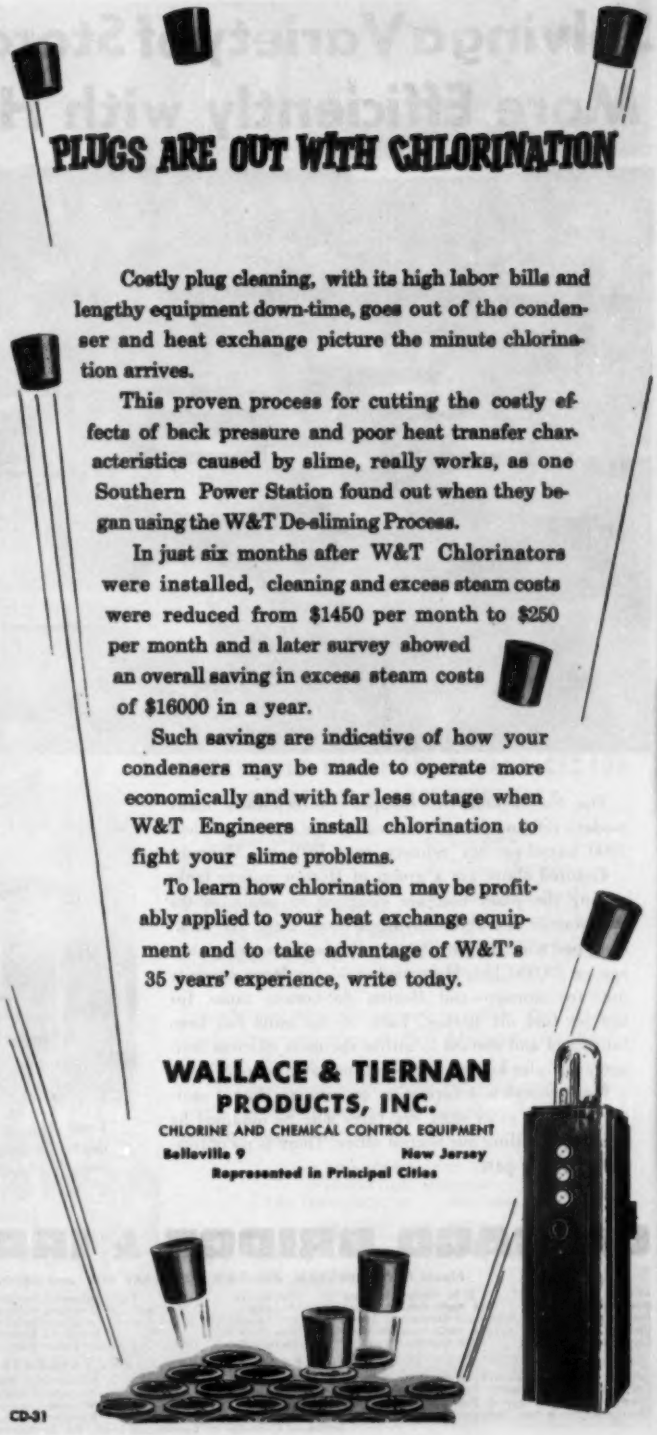
Thiophene or a substituted thiophene having at least one alpha hydrogen is reacted with C Cl_4, an alkali metal hydroxide and an alcoholic solvent at a temperature of 65-210° C. Esters of thenoic acid or its homologues are obtained which can be readily hydrolyzed to prepare the free acids.

U.S.P. 2,553,008. Preparation of Unsaturated Organic Nitriles. W. F. Sager to The Texas Company.

A conjugated diolefin is reacted with HCN in the presence of a solid cuprous salt, such as CuCl, under anhydrous liquid phase conditions and in the presence of a hydrogen halide or a halogen-containing aliphatic compound as a promoter. Unsaturated nitriles are produced.

U.S.P. 2,553,364. Oxidation Process to Form Free Fatty Acids. E. V. Fasce to Standard Oil Development Company.

A mixture of olefins, alcohols, and aldehydes, as obtained in a Fischer-Tropsch or oxo-synthesis operation, is washed in the liquid phase with a dilute aqueous mineral acid, e.g., 5 percent H_2SO_4, and then with an aqueous medium to remove acidic material. The washed organic product is oxidized in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The Continental Oil Company incorporates many modern refining procedures and storage methods at their 7500 barrel-per-day refinery near Billings, Montana.

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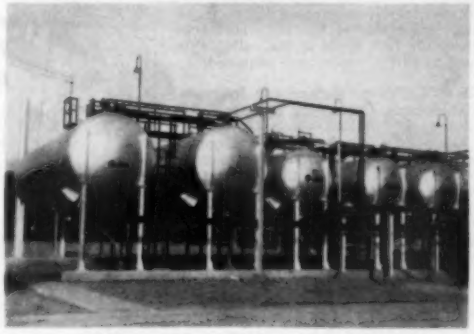
More complete information on similar Horton storage tanks or other steel structures may be obtained by writing or calling our nearest office. There is no obligation on your part.



Two 10-ft. diam. by 35-ft. 6-in and three 8-ft. diam. by 53-ft. 3-in. Horton horizontal pressure vessels at Conoco's Billings refinery.

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Cleveland 15 ..... 2234 Guildhall Building
Detroit 26 ..... 1520 Lafayette Building
Houston 2 ..... 2126 National Standard Building
Los Angeles 17 ..... 1534 General Petroleum Building
New York 6 ..... 3302—165 Broadway Building
Philadelphia 3 ..... 1608—1700 Walnut Street Building
Salt Lake City 4 ..... 331 West 17th South Street
San Francisco 4 ..... 1551—200 Bush Street
Seattle 1 ..... 1331 Henry Building
Tulsa 3 ..... 1626 Hunt Building
Washington 6, D. C. ..... 1128 Cafritz Building

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Sociedade Chibridge de Construcoes Ltda., Rio de Janeiro, Brazil

the liquid phase with air in the presence of a cobalt oleate catalyst at a temperature of 0-200° C. for 1-7 hours. Organic acids are preliminarily obtained.

U.S.P. 2,553,404. Preparation of Aralkyl Cyanides. J. K. Dixon to American Cyanamid Company.

An alkyl aromatic hydrocarbon, e.g., toluene, is heated with CNCl or CNBr at a temperature of at least 525° C. The corresponding nitrile, e.g. phenylacetonitrile, is produced.

U.S.P. 2,553,405. Preparation of Benzonitriles. J. K. Dixon to American Cyanamid Company.

The process of U.S.P. 2,553,404 is here specially applied on the production of benzonitrile from benzene at a temperature of at least 600° C.

U.S.P. 2,553,470. Production of Alkenyl Phenols. H. Pines and J. A. Vesely to Universal Oil Products Company.

A phenol having a substituted hydrogen atom attached to the ring is reacted with an alkadiene having at least one tertiary C atom and in which only one of the double bonds is attached to a tertiary C atom, such as isoprene, at a temperature of —10° to 100° C. in the presence of a complex of stannic chloride with a lower mol weight saturated aliphatic mono-alcohol, mono-ether, or cyclic diether. Alkenyl phenols are produced.

U.S.P. 2,553,785. Bicycloalkylthiophenes. H. Pines and B. Kvetinskas to Universal Oil Products Company.

A thiopene containing a substitutable nuclear hydrogen atom is reacted with a bicycloalkene, such as bicyclo-(2,2,1)-2-heptene at a temperature of —20° to 175° C. in the presence of an acid-acting condensation catalyst, such as a BF_3-catalyst. The corresponding mono- and di-bicycloalkyl thiopenes are produced.

U.S.P. 2,554,268. Process for Preparing Diolefin-Nitrile Copolymers Containing less than Twenty-five Per Cent Nitrile. H. J. Rose and B. M. Vanderbilt to Standard Oil Development Company.

Eighty-ninety parts by weight of a diolefin of the formula CH_2:CR.CH:CH_2 and 6-10 parts of a nitrile of the formula CH_2:CR'.CN, wherein both R and R' are hydrogen or methyl, are emulsified in water. The emulsion is heated to polymerizing temperature in the presence of an oxygen-liberating catalyst. A further amount of 4-11 parts of the nitrile is added in at least two increments while the polymerization is at a level in the conversion range of 20-50 percent.

U.S.P. 2,554,273. Producing Hydrocarbon Resins for Coating Compositions. O. C. Slotterbeck and D. W. Young to Standard Oil Development Company.

A film coating composition is prepared by copolymerization of diisobutylene with butadiene in the presence of a hydrocarbon refrigerant diluent and a Friedel-Crafts metal halide. Details are claimed.

U.S.P. 2,554,459. Ethylene Oxide Process and Catalyst Therefor. R. L.

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Patents

Heider to Monsanto Chemical Company.

Ethylene and oxygen containing gases are passed at temperatures of 225-350°C. over a silver catalyst supported upon a carrier of fused beryllium oxide. Ethylene oxide is produced.

U.S.P. 2,555,518. Photochemical Preparation of Polyphenylalkanes. R. B. Thompson to Universal Oil Products Company.

Phenyl alkanes, such as ethyl benzene or cumene, are condensed in the presence of an alkyl ketone, e.g. acetone, and under the influence of ultraviolet light. Polyphenylalkanes are produced.

U.S.P. 2,555,889. Manufacture of Benzene Hexachloride. A. J. Kolka and H. D. Orloff to Ethyl Corporation.

Benzene is photochlorinated in admixture with 0.02-2.0% of S, Se, or Te, or their chlorides. Benzene hexachloride is produced with a high yield of the gamma isomer.

U.S.P. 2,555,927. Hydroxylation of Unsaturated Compounds. C. M. Himel and L. O. Edmonds to Phillips Petroleum Company.

Aliphatic or cyclic hydrocarbons having at least one olefinic linkage are hydroxylated by contacting them with H_2O_2 in the presence of a low boiling alkyl formate.

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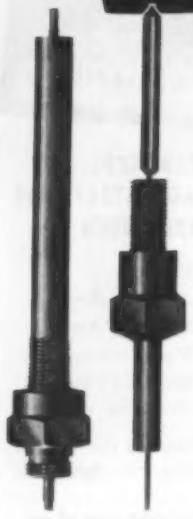

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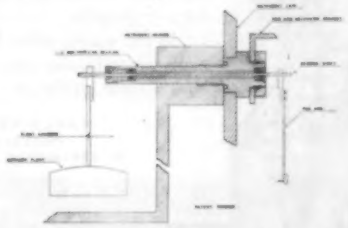

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U.S.P. 2,556,158. Condensation Products of Ethylene and Rubber. J. P. West to Universal Oil Products Company.

Ethylene is treated in the presence of an organic peroxide catalyst at a temperature at least as high as the decomposition temperature of the peroxide. The reaction is carried out under increased pressure in the presence of a saturated hydrocarbon diluent of at least 3 C atoms and a minor amount of natural rubber or a rubbery polymer of isoprene or butadiene. A solid wax-like product is obtained.

U.S.P. 2,556,177. Process for Production of Carbon Disulfide. B. W. Gamson to Great Lakes Carbon Corporation.

CS_2 is produced by atomizing a uniform mixture of certain proportions of a hydrocarbon and elemental sulfur, which is liquid in the range of 300-625°F., into a reaction zone maintained at a temperature of 1000-1800°F., and further treating the resulting mixture of solid carbon sulfur and hydrogen.

U.S.P. 2,556,178. Production of Carbon Disulfide. B. W. Gamson to Great Lakes Carbon Corporation.

The process according to this patent is closely related to that of U.S.P. 2,556,177.

U.S.P. 2,556,799. Heteropolymerization of Sulfur Dioxide and an Unsaturated Organic Compound in the Presence of an Iron Polyphosphate. W. W. Crouch and J. F. Howe to Phillips Petroleum Company.

Butene is reacted with SO_2 while dispersed in an aqueous emulsion in the presence of a ferric polyphosphate. A resin is produced.

POLYMERIZATION AND CONVERSION

U.S.P. 2,552,508. Catalytic Polymerization of Alpha-Olefins. E. F. Peters to Standard Oil Company of Indiana.

An alpha-olefin, such as isobutylene, is contacted in the liquid phase with 0.05-30 percent by weight of a BF_3 catalyst and 5-40 percent by weight of oxygen at a temperature of 70-250° F. Dimers and trimers of the olefin are obtained.

U.S.P. 2,553,426. Method for Terminating a Low Temperature Polymerization Process. H. G. Schutze to Standard Oil Development Company.

Details are claimed of a method for terminating the polymerization reaction between a tert. mono-olefin and a diolefin in a diluent at a temperature not greater than —100° F, and in the presence of a Friedel-Crafts catalyst solution.

U.S.P. 2,553,561. Process of Converting Liquid Phase Hydrocarbon Material. J. E. Evans to Houdry Process Corporation.

Hydrocarbon material to be converted is introduced at least partially in the liquid phase to the interior of a zone enclosed and bounded by a curtain of freely falling particles of contact material. Paired high velocity streams of the hydrocarbon material are flowed upwardly and downwardly, respectively, at a location axial with respect to the zone bounded by the curtain. Both these

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paired streams are engaged in head-on relationship so as to atomize liquid hydrocarbons in these streams by the force of collision of oppositely flowing streams. The atomized liquid is flowed from this location toward the curtain at resulting reduced velocity.

U.S.P. 2,553,944. Electrochemical Conversion of Hydrocarbons. C. H. Schlesman to Socony-Vacuum Oil Company, Inc.

Gaseous hydrocarbons are first continuously subjected to a unidirectional field to produce an ionic discharge and then to a succession of pulses of ionizing electrical energy. Each of these pulses shall have a duration of 1-10 microseconds and be followed by a rest period of substantially greater duration. Various conversion reactions can be carried out by this method, e.g. production of acetylene from methane.

U.S.P. 2,554,245. Complex Friedel-Crafts Catalyst Containing Aromatic Hydrocarbons. R. W. Dornte to Standard Oil Development Company.

In the polymerization of isobutylene at a temperature of —40° to —164° C. a catalyst consisting of a non-gaseous active Friedel-Crafts metal halide in combination with 1-10 mole equivalents of an aromatic hydrocarbon free from olefinic unsaturation is added to the cold feed.

U.S.P. 2,554,263. Gasification of Carbonaceous Solids. K. J. Nelson to Standard Oil Development Company.

Details are claimed of a process for converting solid carbonaceous fuels, such as oil shale and tar sands, into CO-containing gases by endothermic reaction with a gaseous gasifying medium.

U.S.P. 2,554,407. Hydrocarbon Conversion in a Pebble Heat Exchanger. H. J. Hepp to Phillips Petroleum Company.

In a method of reacting hydrocarbons, the hydrocarbons are passed upwardly through a hot solid contact mass under reaction conditions. A mass of relatively cool solid contact material is passed across the top of the hot solid mass. The reaction products leaving the hot, solid mass are filtered through the cooler layer. Tarry materials are deposited on the cooler mass during the filtering.

U.S.P. 2,554,435. Apparatus for Effecting Contact between a Gas and a Downwardly Flowing Contiguous Mass of Pebbles. L. J. Weber to Phillips Petroleum Company.

The construction is claimed of an apparatus for countercurrently contacting gases and solids in a manner which permits thorough contact of the gases throughout the bed of solids.

U.S.P. 2,554,597. Catalytic Process Using Isopoly and Heteropoly Acids. W. C. Starnes and J. B. McKinley to Gulf Research & Development Company.

In a catalytic process, such as hydrogenation, oxidation, or hydro-desulfurization of hydrocarbons, a heteropoly or isopoly acid in flocculent form is incorporated in the material to be catalytically treated. The floc to be employed is obtained by adding a solution of the acid in an organic solvent to a liquid which is a non-solvent for the acid.

U.S.P. 2,554,681. Reduction Activated Peroxygen Catalyzed Synthetic Rubber Emulsion Polymerizations. V. C. Neklutin to U. S. Rubber Company.

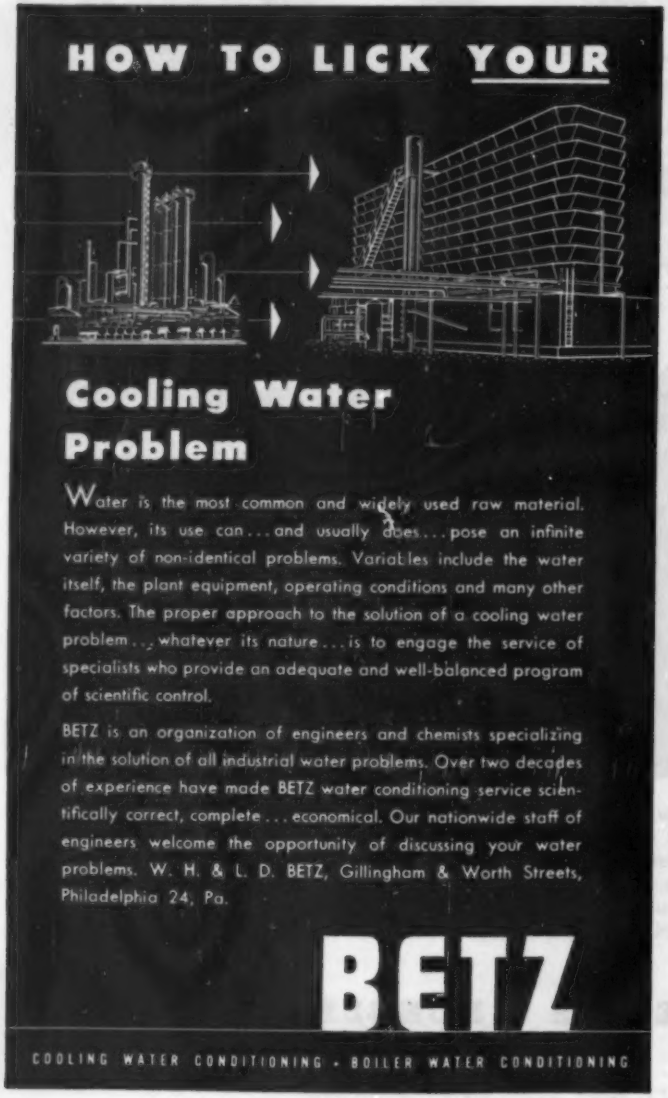
Butadiene-1,3 or a mixture thereof with a compound containing a single $CH_2=C<$ group is emulsion polymerized in the presence of a peroxygen catalyst and ferrous silicate obtained by the interaction of $FeSO_4$ and Na_2SiO_3. The amount of ferrous silicate shall be less than 1 percent. The additive accelerates the polymerization.

U.S.P. 2,555,052. Method of Effecting Contact in a Pebble Heater. H. H. Morse to Phillips Petroleum Company.

A method and a pebble heater reactor are described which are useful in hydrocarbon conversion reactions involving cracking and carbon deposition. Uniform and continuous flow of the pebbles is ensured by the construction claimed, while overheating of the pebbles is prevented.

U.S.P. 2,555,210. Method and Apparatus for Carrying out Catalytic Reactions with Moving Catalyst. P. M. Waddill and F. C. Fowler to Phillips Petroleum Company.

Details are claimed of a continuous process for conducting chemical reactions in vapor phase at elevated temperature with the use of gravitating pebbles. The process can, for example, be used for converting low-boiling hydrocarbons to water-gas with the use of gravitating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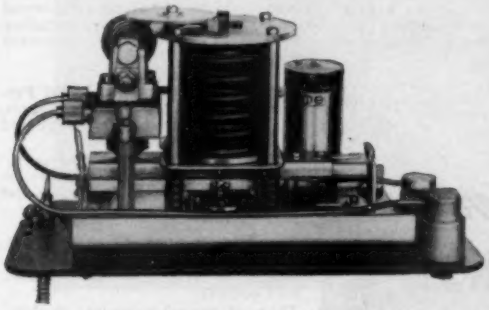

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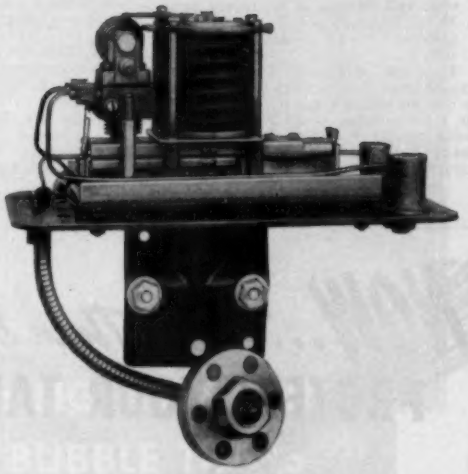

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non-catalytic alumina pebbles heated to 1650-3150° F. and the additional use of catalytic pebbles comprising metallic nickel which are subsequently mixed with the alumina pebbles.

U.S.P. 2,555,298. Dimethylstyrene Polymers and Process of Producing Same. M. G. Sturrock and T. Lawe to Dominion Tar and Chemical Company, Ltd.

Pure 2,4- or 2,5-dimethylstyrene, obtained from di p- or m-xylyl ethane with a decomposition catalyst, is maintained at a temperature of 20-200° C. until a solid, fusible, soluble polymer with an intrinsic velocity of at least 0.1 is obtained.

U.S.P. 2,555,665. Use of a Mono-Ether of Ethylene Glycol to Activate Emulsion Polymerization in the Presence of a Heavy Mercaptan. W. A. Schulze and W. W. Crouch to Phillips Petroleum Company.

Aliphatic conjugated diolefins, such as butadiene or a mixture thereof with styrene, are emulsion polymerized in the presence of not more than 2 percent by weight of tertiary hexadecyl mercaptan and 1-20 percent of a monoether of ethylene glycol.

U.S.P. 2,556,114. Pyrolytic Conversion of Hydrocarbons with the Aid of a Catalyst. R. B. Smith to Sinclair Refining Company.

Details are claimed of a process for the conversion of hydrocarbons with a fluid catalyst. The hydrocarbons are passed in intimate contact with a catalyst in a reaction zone and spent catalyst is stripped of readily vaporizable hydrocarbons and is then regenerated. The reaction, stripping and regeneration are effected in separate zones of a single chamber.

U.S.P. 2,556,198. Process for Converting Hydrocarbon Material. R. C. Lassiat to Houdry Process Corporation.

A stream of hot contact material is fed to the upper portion of a smooth, downwardly converging frusto-conical impenetrable surface over which this material gravitates as a circumferentially complete thin layer. Atomized liquid hydrocarbons are uniformly distributed on this layer from an upwardly enclosed location. Below the frusto-conical surface the particles of the contact material are flowed downwardly as a free falling stream. Conversion of the vaporized hydrocarbons is effected.

U.S.P. 2,556,301. Contacting Solid Particles and Gaseous Fluids. W. Squires, Jr., and L. L. Zahn, Jr., to Standard Oil Development Company.

The construction is claimed of an apparatus for the continuous counter-current contact of finely divided solids and gaseous materials.

U.S.P. 2,556,459. Method for Copolymerizing Styrene and Alpha Methyl Styrene. G. L. Wesp to Monsanto Chemical Company.

Thirty-45 percent by weight of alpha-methylstyrene and 55-70 percent of styrene are emulsion copolymerized at a temperature of 80-110° C., for 4-12 hours in the presence of a water-soluble peroxide compound.

U.S.P. 2,556,488. Manufacture of Polystyrene. L. E. Wakeford, D. H. Hewitt, E. Booth, and R. H. Burkle to The Sherwin-Williams Company.

Styrene is heated in a solvent containing at least one monocyclic or dicyclic alpha terpene in the absence of catalysts. Polystyrene of a molecule weight of 9000-12,000 is obtained.

U.S.P. 2,556,514. Method and Apparatus for Hydrocarbon Conversion. E. V. Bergstrom to Socony-Vacuum Oil Company, Inc.

Details are claimed of a method and apparatus for converting high boiling liquid hydrocarbons to gaseous hydrocarbons with the use of a compact column of particle-form contact material. The method permits uniform distribution of the hydrocarbon charge over the surface of the contact material without excessive accumulation of coky deposits upon the metal surfaces in the conversion zone.

U. S. P. 2,556,651. Shortstopping Agent for Emulsion Polymerizations. L. H. Howland and J. A. Reynolds to U. S. Rubber Company.

In the emulsion polymerization of butadiene-1,3 alone or in mixture with styrene or similar monoolefins, .05-.5 parts by weight of phenyl diethanol amine or beta-naphthyl diethanol amine per 100 parts by weight of the charge material is added after conversion of 60-95 percent of this material to stop further polymerization.

U.S.P. 2,556,857. Low-Temperature Polymerization Processes. R. M. Thomas

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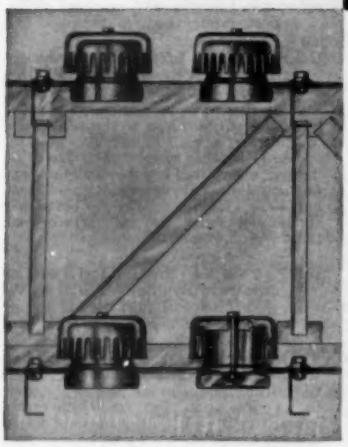

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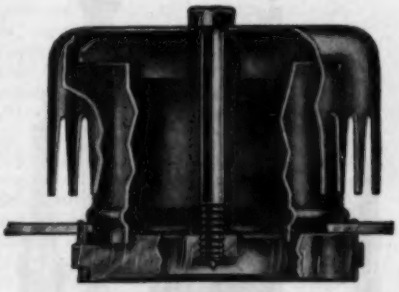

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and A. B. Small to Standard Oil Development Company.

In the low-temperature polymerization of olefins in the presence of Friedel-Crafts metal halides dissolved in a halo-substituted aliphatic compound, a phosphorus oxide is used for pretreating this compound.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,552,737. Process for Producing Synthesis Gas. H. V. Rees to Texaco Development Company.

Synthesis gas is produced from normally gaseous hydrocarbons by treatment with CO_2 and H_2O during flow through a conduit with a porous wall surrounded by a combustible mixture comprising a gaseous hydrocarbon and free oxygen. Details are claimed.

U.S.P. 2,553,398. Method of Effecting Catalytic Conversion. H. V. Atwell to The Texas Company.

In the catalytic hydrogenation of carbon oxides for the production of hydrocarbons and oxygenated hydrocarbons, a mass of inert solid contact material in relatively coarse particle form is disposed within a vertical reaction zone in contact with a heat exchange surface. A CO/H_2 stream containing suspended fine catalyst powder is passed upwardly through the mass of coarse particles with sufficient velocity to maintain these coarse particles in a state of fluidization in the reaction zone but without substantial entrainment of the coarse particles from this zone. Heat is exchanged during the conversion reaction between the fluidized mass and the heat exchange surface. The reaction effluent containing suspended catalyst powder is continuously removed from the upper portion of the reaction zone. A portion of this effluent with the suspended catalyst is recycled.

U.S.P. 2,553,415. Hydrocarbon Synthesis Catalyst. I. Kirshenbaum and K. K. Kearby to Standard Oil Development Company.

In a Fischer-Tropsch synthesis, an iron type catalyst is used which essentially consists of a reduced composite of a major portion of the carbonate of Ca or Ba and a minor proportion of iron. This catalyst is not subjected to disintegration while in use, and carbon deposition thereon is substantially reduced.

U.S.P. 2,553,433, Synthesis of Hydrocarbons. H. G. Vesterdal to Standard Oil Development Company.

A synthesis gas is contacted at suitable conditions with a catalyst consisting of a reduced mixture of a major proportion of an iron oxide, a minor proportion of copper chromite and a minor amount of an alkali metal compound promoter. Deposition of carbonaceous material on the catalyst is substantially reduced in this case and excellent yields of desired products are obtained.

U.S.P. 2,554,054. Process for Producing Butadiene. J. R. Owen to Phillips Petroleum Company.

A mixture of isomeric normal butenes is separated to form a trans-2-butene concentrate, a cis-2-butene concentrate, and a 1-butene concentrate. Each of these concentrates is subjected to separate catalytic dehydrogenation to form butadiene. Higher yields in butadiene are thus obtained than by dehydrogenation of the mixture of butenes.

U.S.P. 2,554,264. Process for Treating Hydrocarbon Synthesis Tail Gas. W. W. Odell to Standard Oil Development Company.

In a Fischer-Tropsch synthesis in which some of the tail gas is recirculated to the reactor along with the fresh CO/H_2-mixture, the tail gas is prepared for recirculation by countercurrently contacting it with a deep mass of finely divided hot solids having at least in part a temperature of 1200-1800° F. for decomposing acetylenic compounds contained therein.

U.S.P. 2,555,185. Recovery of Organic Compounds from Aqueous Carbon Oxide Hydrogenation Product. J. S. Cromeans to Phillips Petroleum Company.

The aqueous phase resulting from a Fischer-Tropsch synthesis is introduced to a fractionator at a point intermediate its top and bottom and is fractionally distilled therein in such a manner that aldehydes and no acids appear in the overhead. Alkaline material is introduced to neutralize all the acids present at a point sufficiently below the point

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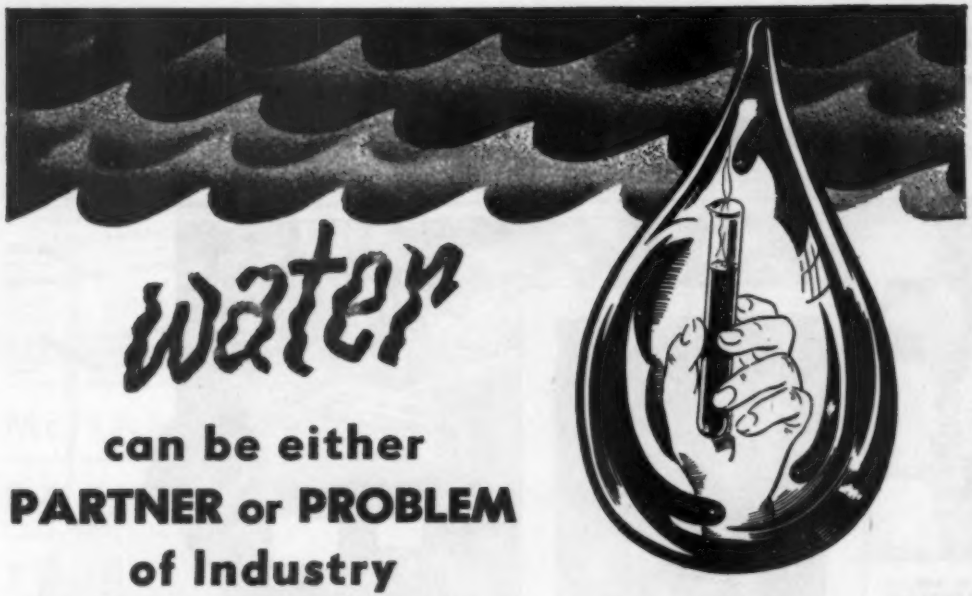

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of introduction of the aqueous phase that no aldehydes are in contact with this alkaline material.

U.S.P. 2,556,275. Process of Treating a Hydrocarbon Synthesis Naphtha Product. C. E. Hemminger to Standard Oil Development Company.

Synthetic naphtha containing oxygenated compounds and obtained in a Fischer-Tropsch synthesis and boiling up to about 400° F. is treated to separate a fraction boiling between 0-225° F. This fraction is subjected to the influence of a dehydrating and polymerizing catalyst containing phosphoric acid at a temperature of 400-600° F. and a pressure about 400 psi. to split off water from the oxygenated compounds, polymerize the olefins thus formed and form a cyclic and aromatic hydrocarbons boiling in the gasoline range. The remainder of the naphtha is treated in a somewhat similar manner, whereupon the treated fractions are combined.

U.S.P. 2,556,861. Hydrocarbon Synthesis Plant. A. Voorhies, Jr., and R. W. Krebs to Standard Oil Development Company.

Details are claimed of a process for a Fischer-Tropsch synthesis to produce high yields of conversion products without excessive deposition of carbonaceous material. A plurality of reaction zones is used.

Corrosion Engineers Slate 1952 Meeting in Galveston

The 1952 annual conference of the National Association of Corrosion Engineers will be held at Galveston, Texas, March 10-14, 1952, the first to be held in the Southwest since 1944. Exhibits and meetings will be held on the Galveston Pleasure Pier, while the Buccaneer Hotel will be convention headquarters hotel.

Eight technical symposia, a general corrosion session and two round table or panel discussion sessions are scheduled for the technical program. Technical committee meetings will be held on Monday, March 10, preceding the formal opening of the conference and also during the remainder of the conference week.

Registration facilities will be available at the Buccaneer and at the Galvez Hotels beginning Monday, March 10. There will be no pre-registration.

1951 ASTM Annual Meeting Approves 57 New Standards

Delegates to the 1951 annual meeting of the American Society of Testing Materials, held at Atlantic City, approved 57 new specifications and tests and acted on more than 200 existing tentatives and standards. The new and revised specifications will be published later this year in the 1951 Supplement to the Book of ASTM Standards.

T. G. Delbridge, Drexel Hill, Penn., retired manager of the Research and Development department of The Atlantic Refining Company, was one of five members of the society who received honorary memberships in recognition of meritorious service.

Truman S. Fuller, engineer in charge of Works Laboratory, General Electric Company, Schenectady, N. Y., was elected president for 1951-1952. L. C. Beard, Sr., assistant director of Socony-Vacuum Laboratories, Socony-Vacuum Oil Company, Inc., New York, is the new vice president.

Phillips Employes Honored

A third one-million man-hours safety period has been achieved without lost-time accident by employes of Phillips Oil Company's refinery at Phillips, Texas. The safety period started on January 13, 1951. The refinery has previously received two certificates of achievement from the API and also has been awarded the Joseph A. Holmes award which is presented by the United States Bureau of Mines. More than 1000 persons are employed at the refinery.

G. E. McKenna, superintendent, said an intensive safety education program inaugurated in 1949 had caused the lost-time average to drop from 38 accidents in 1948 to 6 in 1950. A. W. Sweeney is director of safety and equipment inspection.

Robert Ingalls Dies

Robert I. Ingalls, Sr., president and chairman of the board of Ingalls Iron Works Company, Birmingham, Ala., died July 12.

Ingalls in 1943 established the Ingalls Foundation for charitable and scientific purposes, educational development and research. He is survived by his wife and a son, Robert I. Ingalls, Jr.

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BOOKS of Current Interest

Review and Comment for the Process Man

Gaseous Fuels

ASTM Standards on Gaseous Fuels, American Society for Testing Materials, 1916 Race Street, Philadelphia 3. $1.75.

In its second edition, this standard which is prepared by Committee D-3 on Gaseous Fuels, contains the seven ASTM standards pertaining to this field, and covers the two general subjects of sampling and measurement, and methods of testing and analysis. Four new methods have been included in this edition.

Analysis of natural gases by the volumetric-chemical methods (D1136) is intended for analysis when the complete composition is not required. Analysis of natural gases and related types of gaseous mixtures by the mass spectrometer (D1137), is intended for determination of the complete chemical composition of natural gases and like gaseous mixtures through the C_6 hydrocarbons. The third method concerns measurement of the water vapor content of gaseous fuels by measurement of dew-point temperature (D1142). The fourth method concerns sampling natural gas and is also intended to correlate the size of type of sample with the analysis to be run subsequently on that sample.

On Treating Water

Water Supply and Treatment, Charles P. Hoover, National Lime Association, 925 Fifteenth Street, N. W., Washington 5, D. C., $1.37.

This seventh edition is published in cloth binding by popular demand as the book is being used as permanent reference material on all technical aspects of industrial and municipal water treatment, and also by many colleges as required supplemental text material in Sanitary Engineering courses.

The new edition contains a number of important revisions covering disposal and reclamation of lime sludge, versenate method of determining water hardness, polystyrene base exchange, methods of recarbonating softened water, and contains 99 illustrations. The author was internationally known as a water treatment consultant and authority before his recent death.

LPG Rules Data

Liquefied Petroleum Gas Specifications and Test Methods, Natural Gasoline Association of America, 422 Kennedy Building, Tulsa 3. $1.00.

Generally accepted specifications and test methods for LP-Gases contained in the book were adopted as recommended procedures at the June, 1951, meeting of the NGAA board. Revisions in previous NGAA methods are the result of more than two years of research by the Technical Committee of the association under the leadership of H. A. Montgomery, Warren Petroleum Corporation of Houston, chairman.

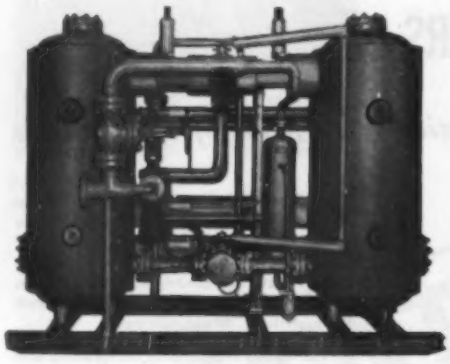
Known as NGAA Publication 2140, the edition contains two new methods, the "LPG Corrosion Test" and "LPG Sampling Method," and includes "LPG Specific Gravity Test (Hydrometer Method)" which formerly was a separate publication. More noticeable changes in the apparatus used are those for vapor pressure, propane residue, and weathering tests.

LPG specification for vapor pressure is specified as 215 pounds, at 100° F. instead of the old 225 pounds at 105° F. "Sulfur Content" specification has been replaced by "Total Sulfur" and "Corrosive Compounds" specifications. Other revisions are largely editorial.

Plant Maintenance

Techniques of Plant Maintenance—1951, Conference on Plant Maintenance, Clapp & Poliak, Inc., 341 Madison Avenue, New York 17. $6.

This publication comprises the proceedings of the Conference on Plant Maintenance held concurrently with the Plant Maintenance Show in January, 1951. A thorough manual on maintenance was compiled throughout the conference. One chapter presents the address by B. J. Beitman on "Training People for Maintenance Work" and out-



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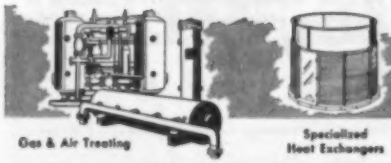

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DU PONT **PETROLEUM CHEMICALS DIVISION NEWS** DU PONT

August ★ *One of a Series of Interest to the Petroleum Industry* ★ *1951*

Brakes Relined with a 'BANG'

New Du Pont explosive rivets save time and money in relining brakes. This saving is especially important to operators of heavy-duty trucks that give brakes real punishment.

Formerly, relining necessitated removing the brake shoes, riveting on new linings, and reinstalling them. Now, in most cases, the job can be done with Du Pont explosive rivets without removing the brake shoes from their anchor plates. The saving is about 50 per cent of the former over-all cost of replacing linings.

And explosive rivets outperform conventional rivets set by hand, as proved by dynamometer tests. Also, road tests show that linings fastened the new way are free from objectionable "brake squeal." It means more time on the road and less time in the shop for equipment regularly hauling loads on a 'round-the-clock schedule.

Du Pont 'Alamask' Odorants for the Petroleum Industry

The ability to smell is one of the five senses on which we depend for knowledge of our environment. Because a vast number of things are slightly volatile, they betray their presence and character by odor in the air we breathe. This is particularly true with many products derived from petroleum.

Recently the Du Pont Company, working with petroleum technologists, developed a line of "Alamask" odorants which are finding application by the petroleum industry. These odorants are generally designed to impart a clean odor without resorting to floral, sweet, or fruity perfuming. They serve well in covering the intense odors of some grades of mineral spirits, or the sulfurous odors which may be present in various types of cutting oils. Some grades of spray oils and heater oils, which have objectionable odors are improved by the addition of the proper "Alamask" odorant.

The Du Pont "Alamask" odorants for petroleum products are oil soluble. They possess high odor coverage values. As little as one pound of a selected "Alamask" was reported valuable in reodorizing nine thousand gallons of #2 type fuel oil. In another instance, one pound of "Alamask" gave a neutral odor to seventeen thousand gallons of selected thinner.

"Alamask" odorants are designed by Du Pont's Fine Chemicals Division to give better sales appeal to petroleum products at low cost. The odor of a petroleum product, when pleasant, may prove of considerable sales value.

Du Pont Gives Representatives Thorough Training to Assist Refiners

TAILOR-MADE PROGRAM COVERS MANY MONTHS

How can a Du Pont Field Representative be most helpful to refiners and marketers of petroleum products? That question led to the development of an intensive training program in the Petroleum Chemicals Division.

Trainees receive much valuable instruction in lecture rooms as a supplement to practical experience gained in TEL manufacturing areas, in laboratories and in the field.

As a result, when a Du Pont representative calls at your refinery or marketing office, he is prepared to help you solve many problems concerning TEL and other petroleum additives. His services also include merchandising aids intended to supplement your own marketing program.

To prepare prospective representatives for this important work, each goes through a specialized training program, lasting from 6 months to a year. Each prospect is carefully selected for the job. Almost all hold engineering degrees. Many have had years of actual refinery experience. The training program is adjusted to meet the individual requirements of each man.

First of all, the new prospect goes to work in the main office at Wilmington. As he progresses he studies technical literature . . . familiarizing himself with all phases of the development, manufacturing, safe handling, distribution and application of tetraethyl lead compounds and other additives.

To thoroughly learn the TEL manufacturing process, the trainee spends considerable time in the manufacturing area. Step by step, he studies each phase of manufacturing. He works on quality-control problems, practices safe handling, helps at the furnaces, studies the ethylation process. He even becomes familiar with shipping details.

At-the-plant work in the manufacture of dyes, grease stabilizers and antioxidants is also part of his program. He gets a thorough background on raw materials, processes, and equipment used.

Safety is stressed throughout the training period. Each man becomes qualified to supervise tank entries and tank car unloadings. He also masters the safe technique for handling TEL in drums. So thorough is a Du Pont representative's safety background that he is able to render valuable service to refiners in helping to train their own blending personnel.

To gain a well-rounded working

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OVER

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED

Thorough Training

knowledge of the Du Pont research activities helpful to refiners, each trainee participates in the work under way at the Petroleum Laboratory. The trainee is also given a brief indoctrination course in refinery processes.

Working with the sales promotion department, the trainee learns how to best apply his knowledge to the varied problems of individual refiners and marketers. How to demonstrate fuel performance with a test car . . . how to make dealer meetings successful . . . these are but a few of the services he learns to perform. Two weeks spent in the New York Office familiarize him with district office operation.

Direct knowledge of the customer's own operations is important, too. Traveling with an experienced representative, the trainee has the opportunity to meet refinery personnel and discuss their work with them.

Through this program, Du Pont is constantly increasing the manpower behind its services . . . making it more valuable to refiners and marketers.

Supervisor of Operations also Directs Instruction of Trainees

In addition to being supervisor of operations for the Petroleum Chemicals Division, B. Gardner Crane directs the trainee instruction program. Gardner Crane came with Du Pont in 1946 after thirteen years with the Ethyl Corporation. With Ethyl's Chicago Division he acted as sales promotion engineer and chief safety engineer. In New York he was in charge of engineering in the safety department. Previous to this, from 1930 to 1933, he was engaged in sales and engineering work for the Acoustical Engineering Corporation in Milwaukee, Wisconsin.

New Data on Engine Deposits Presented by Du Pont Engineer

"Possible Mechanisms By Which Combustion Chamber Deposits Accumulate And Influence Knock" is the title of a paper presented at the SAE Summer Meeting at French Lick, Indiana by L. F. Dumont of the Du Pont Petroleum Laboratory.

It is thought that the new data presented by Mr. Dumont on knocking tendency caused by the volume, catalytic and thermal insulating effects of deposits will be of particular interest to refiners.

In this connection, on the basis of the research reported in the paper, the increase in compression ratio caused by deposit volume accounts for approximately 20 to 40 per cent of engine octane requirement increase, depending on the engine type and type of deposits. It was also indicated that catalysis may not be a contributing factor, especially for leaded fuel deposits, although considerably more work will be required to confirm these results. The thermal insulating effect of deposits appears to be one of the major causes of deposit knocking harm.

Copies of the paper are available through your nearest Du Pont Petroleum Chemicals Division District Office.

This figure appears in the paper, "Possible Mechanisms By Which Combustion Chamber Deposits Accumulate And Influence Knock." In the paper it is reproduced as a cross-section, 50 times enlarged, of piston top deposit showing a new technique for examination and evaluation of the effect of combustion chamber deposits on knocking characteristics.

LITERATURE AVAILABLE

The Petroleum Chemicals Division of Du Pont has published a wide variety of material of interest to the petroleum industry. This includes technical papers, bulletins, reports and memoranda as well as equipment operation bulletins, safety regulations, tank cleaning data, marketing aids and the like.

Any of this is available on request to your nearest Du Pont Petroleum Chemicals Division District Office. A partial listing of available material is shown below:

Possible Mechanisms By Which Combustion Chamber Deposits Accumulate And Influence Knock . . . . . Serial A-2087a

Tank Talk—A new 52-page booklet designed for easy reading by tank cleaning personnel . . Serial A-1134

Blending calculator for Du Pont TEL Compound (Aviation Mix) . . . . . Serial A-1210

Exhaust Valve Rotation—A resume covering the use of mechanical devices to improve valve life . . . . . Serial A-656

The Effect of Hydrocarbon Structure on the Road Antiknock Performance of Motor Fuels . . . . . Serial A-505

Working with the Petroleum Industry—information about Du Pont's TEL manufacturing and research facilities . . . . . Serial A-8620

Antiknock Antagonists—by H. K. Livingston, Jackson Laboratory.

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Books

lines the method employed by the Maintenance Analysis Division of the Goodyear Tire & Rubber Company, Akron, Ohio, to train and supervise maintenance personnel. Each chapter also contains the question and answers that followed each address.

H. E. Shaw of Westinghouse Electric Corporation, discusses maintenance costs, control and budgeting; D. G. Jamieson representing Canadian Synthetic Rubber, Ltd., presents planning and scheduling maintenance operations, while R. A. Bell of American Viscose Corporation, gave pointers on controlling the costs of maintenance.

The major value of the text is the presentation of successful methods and programs as proved adaptable and acceptable by specific organizations under certain conditions.

Japanese Experiments

Information Circular 7611, Bench-Scale Studies of the Fischer-Tropsch Synthesis over Iron, Nickel, and Nickel-Cobalt Catalyst (Japan), Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13. Free copy.

Successful laboratory-scale studies of the use of catalysts other than cobalt in the production of synthetic liquid fuels from coal by the Fischer-Tropsch process, carried out in Japan during World War II, are described. The publication is a translation of two reports by Shiro Watanabe, research chemist of the Hokkaido Synthetic Petroleum Works, Inc., of Japan. Edited by R. C. Grass, former research chemist of the Bureau's Synthetic Fuels Research Branch at Bruceton, Pa., he also contributes a preface sketching in road terms the Japanese wartime efforts to produce synthetic liquid fuels. The report, highly technical, gives full details regarding each experiment covered. Text is supplemented by numerous tables and diagrams.

New Alcoa Plant Will Use Texas Lignite Near Waco

A new aluminum smelting plant, the first in history to use lignite (subbituminous coal) for fuel, will be built by Aluminum Company of America, which has applied to the Department of the Interior for a certificate of necessity to begin immediate construction of the plant at one of several alternate locations approximately 60 miles south of Waco, Texas.

The plant will have a capacity of 85,000 tons of aluminum annually when completed, with production expected to start in the early fall of 1952.

The feasibility of using processed Texas lignite as a major fuel source resulted only recently due to new developments in fuel technology, officials declared.

Currently, Alcoa's Point Comfort, Texas, plant is being enlarged to produce an additional 35,000 tons annually. Also under construction by Alcoa is a new 85,000-ton smelting plant at Wenatchee, Washington, and a new plant at Bauxite, Ark., for the refining of bauxite ore into alumina (aluminum oxide).

Big Attendance Expected By ISA at Houston Meet

A quarter of a million invitations have been issued for the Sixth National Instrument Conference and Exhibit of the Instrument Society of America, Sam Houston Coliseum, Houston, September 10-14. This meeting will include the American Institute of Physics, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Institute of Radio Engineers, the National Association of Corrosion Engineers, the Gulf Coast Spectrographic Society and the Pipe Liners Club. Officials anticipate an attendance of 10,000 or more. Speakers will include more than 50 "outstanding scientists and technical specialists from government, and educational and indus-

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trial organizations," it was said.

James Harrop, general superintendent of Humble Oil & Refining Company at Baytown, Texas, will speak on "Instrumentation in Petroleum Refining," September 12, at the "SAMA Luncheon." The luncheon is open to all instrument manufacturers and distributors and will be held in the Rice Hotel, Houston.

Elected Vice President

Andrew J. Hooper, a member of the organization for 19 years, was elected vice president of the Maintenance Engineering Corporation of Houston. Before joining Maintenance Engineering he was assistant chief technologist at the Shell Petroleum refinery near Houston. He is a Tulane University graduate.

Instrumentation Symposium Is Scheduled in Houston

Texas A. & M.'s symposium on instrumentation for the process industries, the sixth annual session, will be held September 13 and 14 this year at Sam Houston Coliseum, Houston, in conjunction with the national meeting of the Instrument Society of America.

Officials of the School of Engineering, Chemical Engineering department, said the symposium would have three sessions on Thursday morning and afternoon and Friday morning. Session topics are: 1) Measurement and Analysis in Control, 2) Transmission and Control Systems and 3) Instrumentation Application.

Pre-registration at $2 per person is urged. These should be sent to R. E. O'Neill, treasurer of the Steering Committee, Industrial Scientific, Inc., Box 1017, Houston.

Oil from Tar Sands Is Reported by Californians

Almost instantaneous separation of oil from tar sands, such as the Athabaska deposit of Alberta, is claimed for a new chemical process developed by Chemoil Company of Corona Del Mar, Calif. Chemical reaction takes place at atmospheric conditions and no foreign matter is introduced which would have to be removed through further treatment, the developers say.

Demonstrations of the process are being conducted at a pilot plant at Balboa, Calif. The tar sand itself provides the diluent that under controlled conditions causes separation of oil and sand. Only heat, water and the sands are required for operation of the process, according to Chemoil officials.

Tests indicate that a ton of tar sands will yield approximately one barrel of high grade oil at a cost of approximately 92 cents a barrel, Chemoil officials said. Of commercial value also are coke and sulfur, both by-products generated by the process.

Fluor Corporation, Ltd., controls the sulfur recovery process, which would make possible a high economic yield of sulfur, based on a production of 4000 barrels per day of oil from the tar sands. The Fluor sulfur process will be available to prospective licensees of the Chemoil process.

Stanolind Receives Safety Awards from Homes Group

Eleven certificates in recognition of outstanding achievement in the field of safety have been awarded to Stanolind Oil and Gas Company by the Joseph A. Holmes Safety Association.

One of the certificates was a company-wide citation for the firm's safety record over the three-year period 1948-1950. During that time, an average of 6972 employes worked a total of 44,646,103 manhours, with an accident frequency rate of only 3.36 accidents per million manhours work. By contrast, the industry's frequency rate for the same period was 10.96.

Another award went to the Gilliam gasoline plant, Vivian, La., in the Central division, which recorded no lost-time accidents from March 3, 1935, through December 31, 1950. The plant's eight employes worked 250,337 manhours during the period.

Sun Laboratory Honored

Honoring a 15-year accident-free industrial safety record, the American Petroleum Institute last month presented its Accident Prevention Award to personnel of the Sun Oil Company Automotive Laboratory, Marcus Hook, Pennsylvania.

The API award is given only when an industrial unit reaches one million man-hours without a disabling injury, which goal was reached early this year. The no-accident record continues unbroken.

The award was accepted by A. Ludlow Clayden, manager of the laboratory, from Walter Boon, Marcus Hook Refinery safety director, acting on behalf of the API.

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6	5.60	7.15	1.50
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2	1.80	2.40	1.50
3	2.00	2.70	1.50
4	2.15	3.00	1.50
6	3.00	5.00	1.50
8	3.90	7.10	2.50
10	4.50	10.30	2.50
12	4.90	13.50	2.50
14	5.10	16.20	2.50
16	6.00	19.20	4.00

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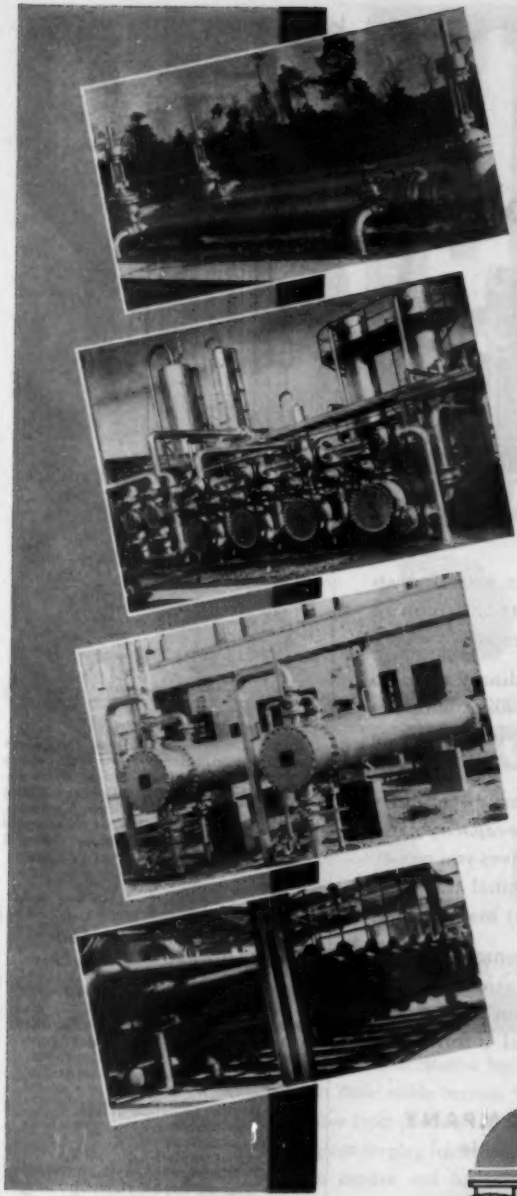

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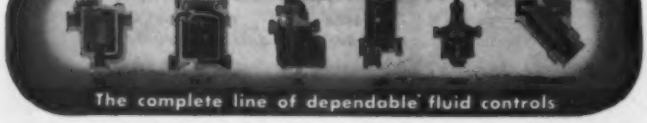

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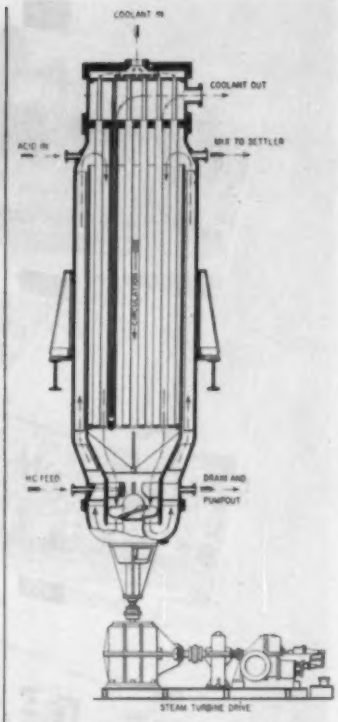


CORRECTION — Above is shown the correct Figure 1 of D. H. Putney's "Many Improvements Noted in Alkylation Plant Design" which appeared in the June, 1950, issue of PETROLEUM REFINER. This sketch, "Vertical Contactor, Lance Type Tube Bundle," shown above should be substituted for the erroneous Figure 1 which appeared on page 89 of that issue.

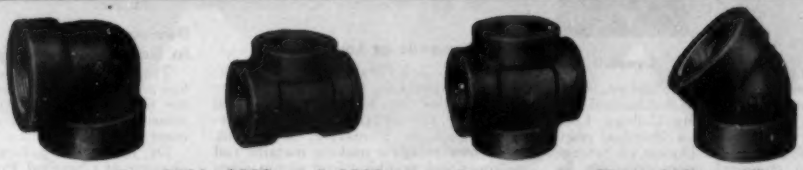
Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

2-Amino-2-phenylethanol
α-Allylpyridine
Allylacetylene
Cyclohexandiol-1,2
4,4'-Diaminodiphenylamine
6-Cyano-2-naphthylamine
Cobalt butyl phthalate
1-Chloro-2-bromoethylene
3-Hydroxypiperidone
2,6-Dihydroxyquinoline
2,3-Dimethylhexanol-4
2,3-Dimethylbutadiene
Ethyloctadecyl sulfide
Ethylsulfinic acid
Chlorofumaric acid
Isophthalaldehyde
Carboxylbenzoquinone
Thiobenzoic acid
Molybdenum carbonyl
Chromium carbonyl

STRENGTH

for Safety and Long-Time Service



For 2000, 3000 and 6000 pounds service — Sizes 1/8" to 6"

SCREW END TYPE

For schedules 40, 80 and 160 pipe — Sizes 1/8" to 4"

SOCKET WELD TYPE

Vogt Ells, Tees, Crosses, etc., are forged from carbon steel or various alloys to meet specific operating conditions. Catalog F-9 will aid you in their selection and proper application.

Shocks and stresses imposed by high pressures and high temperatures are taken in their stride because Vogt fittings are uniform in structure, fine grained, and free from porosity . . . the superior product of laboratory controlled materials and giant forging hammers and upsetters. These properties also give higher resistance to erosive and corrosive conditions, thereby adding to service life expectancy in steam plants, petroleum refineries, chemical plants and related industries.

HENRY VOGT MACHINE CO., INC.
Louisville 10, Kentucky
BRANCH OFFICES: NEW YORK • PHILADELPHIA • CLEVELAND • CHICAGO • DALLAS

Vogt

DROP FORGED STEEL FITTINGS

About EQUIPMENT and SERVICE Suppliers

Campbell Appointed Chief Engineer of Centrifix

A veteran of 31 years in the chemical engineering field, Charles L. Campbell was appointed chief engineer of Centrifix Corporation and will direct design development of the Centrifix line of purifying equipment. He will also offer design and fabrication assistance for special applicances. For the past seven years Campbell was chief engineer with the Diamond Alkali Company, Painesville, Ohio, and prior to that, was associated with the Barium Reduction Corporation as chief engineer.

Campbell

Campbell earned his mechanical engineering degree at City College, London, and subsequently a chemical engineering degree and a Doctor of Science degree in chemical engineering at Le Sorbonne, Paris.

Dowell Promotions Transfer Three in Southwest Area

Ray S. Ousterhout was transferred by Dowell Incorporated from Odessa, Texas, to Midland, Texas, and promoted to district sales engineer. A graduate of the University of Tulsa, Ousterhout joined Dowell in 1943.

Clay Courter, formerly a sales engineer at Hobbs, N. M., will replace Ousterhout at Odessa. Courter, a graduate mechanical engineer from the University of Oklahoma has been with Dowell since 1947.

Warren Sallee, who replaces Courter at Hobbs, formerly was a service engineer at Snyder, Texas. He holds a B.S. in M.E. from the University of Texas.

Cook Expands at Louisville

C. Lee Cook Manufacturing Company, Inc., plans to increase its production facilities by approximately 50 percent by the addition of manufacturing area at its Louisville, Ky. plant. Many new tools for making metallic rod packings and graphitic iron piston rings are now in operation, the company said.

Clary

Cooper

O'Loughlin

Prince

Davison Announces Changes In Research-Development Heads

The Davison Chemical Corporation has announced a new superintendent for the Curtis Bay plant and three promotions within the Research and Development division.

Dr. Joe D. Clary, formerly a technical director of Chemical Products Corporation of ,Cartersville, Ga., was named

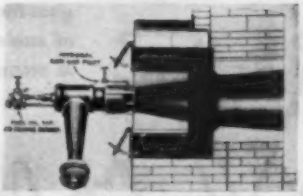
10,000 HOURS CONTINUOUS SERVICE "ON STREAM"

. . . not unusual for

THE NATIONAL AIROIL TANDEM COMBUSTION UNIT

TEN THOUSAND HOURS WITHOUT SHUTDOWN IS NOT "OVERTIME" for process oil heaters fired by the NATIONAL AIROIL TANDEM COMBUSTION SYSTEM firing dirty, wet refinery gas; uncut asphalt; refinery fuel oils . . . HOURS ARE LONG . . . PROFITS ARE HIGH . . . YOU will realize high profits from YOUR heaters when TANDEM COMBUSTION UNITS are specified.

Detailed information sent upon request on your business letterhead.

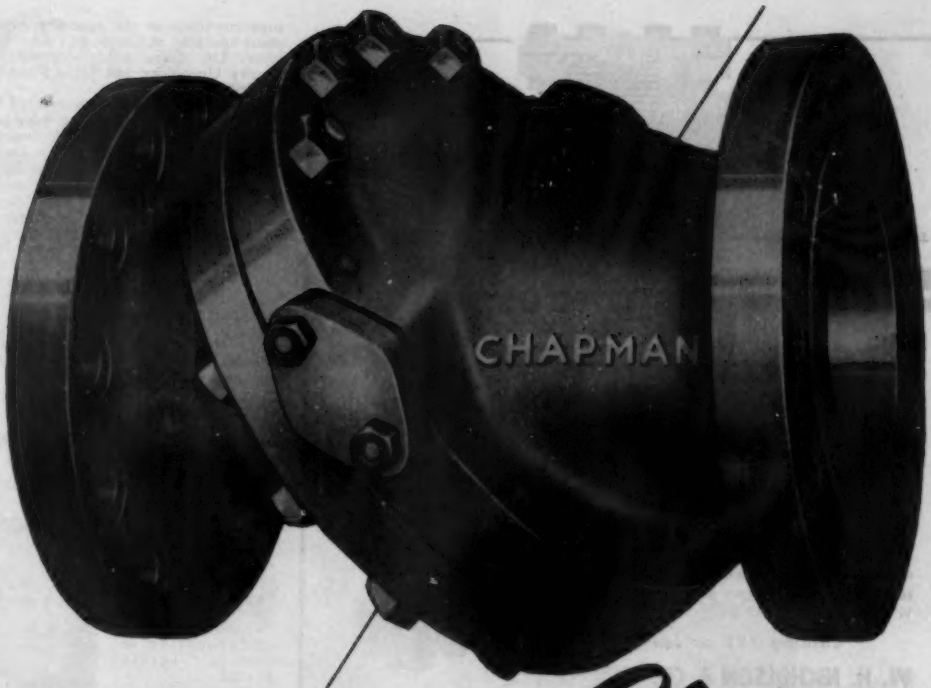


CHEMICAL-PETROLEUM DIVISION

NATIONAL AIROIL BURNER CO., INC.

Main Office & Factory: 1234 EAST SEDGLEY AVENUE
PHILADELPHIA 34, PA.

SOUTHWESTERN DIVISION: 2512 SOUTH BOULEVARD
HOUSTON 6, TEXAS



YOU GET

Cushioned Closing

WITH

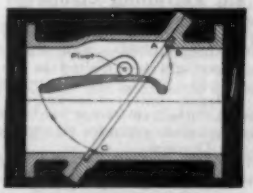
CHAPMAN

TILTING DISC CHECK VALVES

There's no impact on closing — with this valve by Chapman. The balanced disc rides the flow smoothly — uses the fluid or gas itself to cushion the closing action. The disc lifts away from the seat easily on opening; closes quickly, positively—yet quietly.

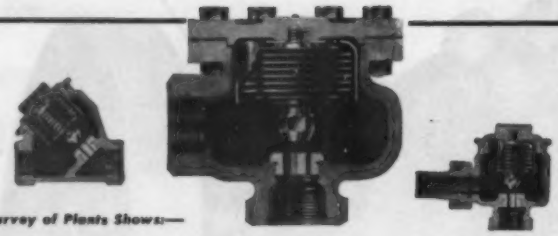
Consequently, there's no rubbing on the seats—little wear on hinge pins and bearings. Repair needs are at a minimum — maintenance costs low.

Chapman Tilting Disc Check Valves are available in either iron or steel. Write today for catalog with complete technical information.



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

The Chapman Valve Manufacturing Company
INDIAN ORCHARD, MASSACHUSETTS

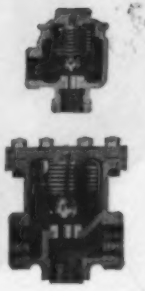


Survey of Plants Shows:—

15 of 20 Engineers Prefer Nicholson Traps

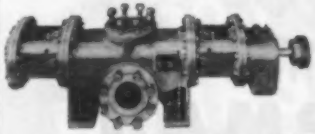
To determine the best steam trap on which to standardize, a large processing firm recently asked their plant engineers for their preference. In 15 out of 20 plants the choice was Nicholson.

The repeated adoption of Nicholson steam traps in plants currently in big "cost-reduction-through-modernization" programs is another indication of their advanced features. To learn why an increasing number of leading plants are standardizing on Nicholson thermostatic steam traps send for our catalog. 5 types for every power, heat, process use; size ¼" to 2"; press. to 225 lbs.



Catalog 751 or see Sweet's

W. H. NICHOLSON & CO. 207 OREGON STREET WILKES - BARRE, PA.



FOR ONLY $80 MORE ...you get a pump WORTH $800 MORE!

● Pump Shown: new External Gear & Bearing Bracket Type for non-lubricating fluids, semi-fluids. Capacities 1-700 GPM: Discharge 1000 PSI for viscous liquids, 300 PSI for water.

Sier-Bath SCREW PUMPS

TYPICAL PURCHASES

A. You buy a cam, lobe, vane or gear type pump for $770. — pay another $2580. for a slow speed motor (if you can get it), or for a faster motor, plus reduction gearing.

TOTAL: $3350.

B. You buy a Sier-Bath Screw Pump for $1570. — but pay only $1860. for a high speed motor — and forget about reduction gearing!

TOTAL: $3430.

CONSIDERATIONS

WITH PURCHASE B you invest your money in the pump — not in the motor. This is possible because Sier-Bath Screw Pumps can be direct connected at high rpm — up to 1800 — and maintain lower liquid velocities than is possible with other types of rotary pumps. The advantages of purchase B over purchase A are: you get a pump that will provide more dependable service, cost less to maintain, and last longer — plus a motor that is smaller, less expensive, but just as serviceable as the $2580. slow speed motor. All told, for $80 more you get a pump worth $800 more!

Sier-Bath GEAR and PUMP CO., Inc.

For Further Information See Your Local Sier-Bath Representative, or write to

9249 HUDSON BLVD., NORTH BERGEN, N. J.

Also Manufacturers of Gerotor Pumps, Gear Couplings, and Precision Gears

superintendent of the specialty catalyst plant operated at Curtis Bay near Baltimore. Dr. Clary holds degrees from Emory University and Ohio State University.

Dr. Albert H. Cooper, appointed head of the Research Engineering department of the Research and Development division, recently transferred to Davison from Bucknell University where he was professor and head of the department of chemical engineering. He holds degrees from the University of Tennessee and Michigan State College.

Walter K. O'Loughlin, appointed manager of the development department of the same division, holds degrees from the Catholic University of America.

Kenneth E. Prince recently joined the division as head of the patent department. He is a member of the Tennessee, South Carolina, Federal and Patent Office bars, and formerly was with Phillips Petroleum Company as a patent solicitor.

Borchardt New Vice President Of Sales for Worthington

A. H. Borchardt has been elected a vice president of Worthington Pump and Machinery Corporation and will have the over-all responsibility for the sale of the corporation's entire line of pumping equipment, including centrifugal, reciprocating and vertical turbine pumps.

Borchardt

Borchardt, a Columbia University ME graduate, first joined Worthington's erecting and testing department, then became successively draftsman, field engineer and sales engineer. In 1921 he was made assistant manager of the Centrifugal Pump Sales department, becoming its manager in 1929. He then became successively sales manager of the Harrison plant, manager of the Commercial Engineering department and in 1934, Assistant Vice President and Manager of Centrifugal Pump Application and Sales Divison.

A past president of the Hydraulic Institute, Borchardt also is a member of many other technical societies.

M-H Hires New Engineers In Big Recruiting Campaign

A 40 percent increase in the engineering staff of Brown Instrument Division of Minneapolis-Honeywell Regulator Company will be effected in the near future when 103 engineers, recruted from 30 colleges, universities and technical schools, graduate from an intensive training course given for all employes by Brown Division.

The personnel increase is a result of expanding business, chiefly for industrial process instruments for defense and defense-supporting industries, according to company officials. A large percentage of the new men comprises graduates of last December and June. Brown recruiters ranged campuses from Main to Virginia and west to Ohio.

Cooper-Bessemer Official Wins Award from Ohio State

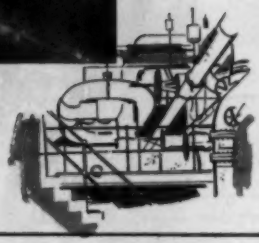
Ralph L. Boyer, vice president and chief engineer of The Cooper-Bessemer Corporation, Mount Vernon, Ohio, has

From interpretation to installation . . .

GRINNELL PREFABRICATED PIPING

assures greater customer satisfaction through its five-point program of

Quality Control



The bending operation illustrated above is an example of Grinnell QUALITY CONTROL *in action* . . .

The tubing shown is made from a chromium alloy steel forging, turned and bored. Outside diameter is 14¾ inches; wall thickness 2⅛ inches. Temperatures of the tubing within the bending furnace were maintained and controlled within 20°F of specified temperatures. Bending was done with such skill and rapidity as to permit a temperature drop of only 100°F at the inside surface of the tubing. Maximum thinning was only .06 inch.

Designed for a central station power plant to accommodate 1500 PSI and 1050°F, this is typical of Grinnell's engineering knowledge which assures prefabricated piping of the right kind — for all types of installations no matter how complex.

QUALITY CONTROL is the result of Grinnell's 100 years of practical experience in the field of piping. Delivery of prefabricated piping subassemblies to exacting engineering requirements which meet all governing code requirements is assured by Grinnell Quality Control, which includes:

- Interpretative engineering
- Metallurgical research
- Specialized facilities
- Skilled personnel
- Rigid inspection

ECONOMY of specifying Grinnell prefabricating piping results from:

- One source for design, interpretation and fabrication
- Coordination of shop production under ideal conditions
- Elimination of waste by paying only for finished material delivered
- Reduction in field erection time

Write for the booklet, Grinnell Prefabricated Piping.

GRINNELL

WHENEVER PIPING IS INVOLVED

GRINNELL COMPANY, INC., Providence, R. I. Warehouses: Atlanta • Billings • Buffalo • Charlotte • Chicago Cleveland • Cranston • Fresno • Kansas City • Houston • Long Beach • Los Angeles • Milwaukee • Minneapolis • New York Oakland • Philadelphia • Pocatello • Sacramento • St. Louis • St. Paul • San Francisco • Seattle • Spokane

Double Trouble for coke deposits!

...with the Lagonda 1100 Series Tube Cleaners

Meet the scrappy combination that has made the '1100' a byword in the industry for fast, thorough cleaning of refinery still tubes . . . The combination that cuts 'down time', gets you back on stream faster, and reduces maintenance costs on still tubes.

❶ **LAGONDA 1100 SERIES MOTOR** High-speed, heavy-duty; all wearing parts of alloy steel, precision ground to give maximum efficiency over a long life. BALL thrust bearings at both *front* and *rear* of motor plus exclusive Lagonda pressure lubrication insure smashing power to cutter head for faster, more thorough cleaning – saving costly minutes and hours in 'down time'.

❷ **LAGONDA CUTTER HEAD** Tough on coke deposits, tender on tubes. Patented trackless design of cutter teeth results in each tooth contacting at a slightly advanced point at each revolution, removing all encrustation without cutting tooth design in tube wall. Keen, long-lasting edges of cutter teeth and ability of entire unit to take repeated hard blows without failure are attained through the use of selected alloy steels and expert heat treatment. Simplicity of construction gives utmost ruggedness yet permits easy disassembly for repair.

IF IT'S TUBE CLEANING IT'S Lagonda

BULLETIN Y-29 contains complete details and specifications on the full line of Lagonda Tube Cleaners. Write for your copy today.

Y-302

1901 ELLIOTT Company 1951

LAGONDA DIVISION • SPRINGFIELD, OHIO

Plants at: JEANNETTE, PA. RIDGWAY, PA. • AMPERE, N. J. SPRINGFIELD, O. • NEWARK, N. J.
District Offices in Principal Cities

been awarded the Lamme Medal for 1951 for the "development of today's important gas-diesel engine and the high compression spark-ignited gas engine."

The annual conferring of this medal, one of Ohio State University's highest honors, for meritorious achievement in engineering is a result of an endowment to Ohio State University by Benjamin G. Lamme, former Chief Engineer of the Westinghouse Corporation who initiated practically all design calculations that go into the construction of generators and motors. Boyer is the twenty-fourth Ohio State graduate so honored.

Cochran Appointed Rocky Mountain Area Supervisor

Orville Cochran recently was appointed supervisor of gas products and Nordstrom valves for the Rocky Mountain area by the Kansas City office of Rockwell Manufacturing Company.

Cochran

Cochran, who has been affiliated with Rockwell Manufacturing Company for over twenty-five years, has during that time served as head of the Service Department, as sales engineer and as a field representative for Nordstrom valves in the Kansas City territory.

Rockwell's main office is located in Pittsburgh.

James Elected Vice President McDonnell & Miller Research

John W. James, a McDonnell & Miller employee since 1948, was recently elected vice president in charge of research. James, who inaugurated an intensive research program for McDonnell & Miller when he joined the organization, is a graduate in mechanical engineering of Oregon State College and holds an MS in ME from the University of Wisconsin. He was an instructor, thesis and research adviser at Polytechnic Institute of Brooklyn for three years, and spent five years designing and developing domestic oil burners, furnaces, etc. He is widely known in the heating industry for his eight years service as technical secretary of the A.S.H.V.E. as well as participation in professional societies. He has published a number of books and papers related to his work.

De Laval Elects President And Three Vice Presidents

James P. Stewart, formerly executive vice president and a member of the staff since 1946, has been named president of De Laval Steam Turbine Company. He is already serving as president of Hydraulic Institute, a trade association of the pump manufacturing industry.

Wencel A. Neumann, Jr., was elected vice president of industrial sales and will be responsible for the industrial and commercial sales of De Laval products. He has been associated with the company since 1946, and was promoted from the managerial position of the IMO-De Laval Products Division.

H. G. Bauer, elected vice president of engineering, will continue as manager of marine sales as well. Bauer joined the

WIRE MESH

Maybe it all *does* look pretty much the same at first glance. But when a firm has been making wire mesh for 70 years man and boy, there's bound to be a little more to it than meets the eye — a little more know-how in engineering and weaving, a little more quality in the product, a little more service and satisfaction for the user.

JELLIFF WIRE MESH is woven in all ductile metals
JELLIFF WIRE MESH is woven in all commercial weaves
JELLIFF WIRE MESH is woven in widths up to 72 inches
JELLIFF WIRE MESH is economical. Every foot runs true to the specifications.

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JELLIFF WIRE MESH is a quality product and has been for 70 years. You can depend on it.

Write today for full details about JELLIFF WIRE MESH, JELLIFF WIRE MESH PRODUCTS, and JELLIFF'S CONSULTATION SERVICE on wire-mesh engineering. Address Department 16.

THE C. O. JELLIFF MFG. CORP.
DIPPING BASKETS · LEKTROMESH · RESISTANCE WIRE
WIRE MESH PARTS · WIRE CLOTH · STRAINERS · FILTERS
SOUTHPORT CONNECTICUT

PLAN TO ATTEND

The Instrument Industry through the necessities of the present emergency has reached a high peak of development, and is ready to consult with you and your engineers and operating men on the baffling problems of efficiency and economy, which are fast becoming the real headaches of plant operation.

Post yourself on the latest advances in instrumentation by attending.

Bring your engineers and operating executives. No charge—admission by registration only.

Write for preliminary program to the Instrument Society of America, 921 Ridge Ave., Pittsburgh 12, Pa.

An EASIER WAY
To Remove Packings
Use DURA HOOKS

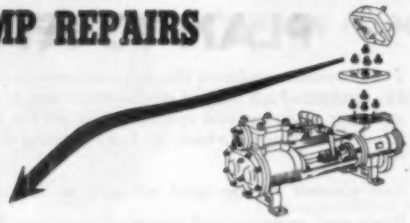
Rugged, flexible, hand-tools that "work around corners" for removing old packing from stuffing boxes. They SAVE TIME . . . put an end to fussing and cussing . . . improves your manpower efficiency. WRITE FOR DURA HOOK Bulletin DHPR covering SIZES and PRICES.

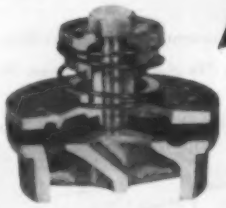
★ All Steel Flexible shaft
Tempered tool steel corkscrew bit

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

REDUCE PUMP REPAIRS
4 WAYS





1. **Prevent STEM and SPRING breakage.** Exclusive double shock absorber built into Sims valves stops impact shock.
2. **Stop wear.** Long guide of ROTATOR prevents cocking of DISC—assures even opening.
3. **Keep seating surfaces leak free.** Only Sims guarantees the valve DISC will rotate every time it lifts.
4. **Stop valve slam and knock.** Quiet operation is gained by cushioning moving parts and cutting resistance to flow through the SEAT . . . with patented **inclined ribs.** This reduction of resistance allows cylinders to fill completely. Pump capacity is increased 20%.

Sims valves are made in sizes from 2¾" to 15¼" to fit any reciprocating pump. Valves supplied ready to install—cast in individual units or in complete plates.

SIMS PUMP VALVE CO., INC.

New catalog shows how Sims valves fit any pump—how they work—efficiency and comparison charts. Send for your free copy today.

145 HUDSON ST., NEW YORK 13, N. Y. • M & M BLDG., HOUSTON, TEXAS

Stewart

Neumann

staff in 1937, was elected a vice president in 1949, and served as an executive engineer until his present promotion.

Charles A. Jurgensen, will continue to serve as works manager but in addition adds the responsibilities of vice president of manufacturing. He joined De Laval in 1931.

Service Representatives in Houston, Pittsburgh Named

Conoflow Corporation, Philadelphia, has extended the company's field service to embrace the Houston and Pittsburgh territories. Conoflow has recently started to service many government contracts essential to national defense, in addition to filling the vital needs of private industry. The resultant increased demand for its standard line of manufacture as well as the recent development of several new products, particularly in the petroleum and chemical line, motivated the wider coverage in representation.

Harold G. Jones Company, 502 Empire Building, Pittsburgh, has been appointed manufacturer's representatives serving Pittsburgh, western Pennsylvania and northwestern West Virginia, and M. N. Aitken Company, 5960 Kansas Street, will represent Conoflow in Houston and the surrounding trading area extending from Freeport to Lake Charles, La.

Dr. Daubert, U of Pittsburgh, Joins Koppers Research Staff

Dr. B. F. Daubert, research administrator and research professor in the chemistry department of the University of Pittsburgh since 1943, has been named assistant manager of the laboratory section of Koppers Company, Inc., Pittsburgh.

Author of more than 70 articles published in chemical magazines, Dr. Daubert is active in ACS, is affiliated with many scientific organizations and is listed in Chemical Who's Who, American Men of Science, and Who's Who in American Education. He holds B.S. and Ph.D. degrees from the University of Pittsburgh School of Pharmacy.

V. D. Anderson Adds Personnel To Steam Specialty Division

Three engineering executives, added to its steam specialty division by the V. D. Anderson Company, Cleveland, Ohio, will head up development work on high efficiency purifiers, both internal and line types.

Bruce R. Wright is a mechanical engineering graduate from Carnegie Tech and specialized in development and special application of high efficiency purifiers as a consultant for 12 years.

John T. Odbert was graduated from Cornell in mechanical engineering and holds a M.S. in C.E. from M.I.T. For

try SANTOLENE C to stop tanker corrosion

Internal corrosion in tankers may cost you as much as $90,000 a year in maintenance, including cost of critical materials, down time and manpower. Examine Santolene C, corrosion inhibitor for light petroleum products, as a means of controlling tanker corrosion.

Santolene C, added to the light petroleum cargo, is believed to form a protective coating on metal. This coating remains to protect the ship when condensation covers the empty hold or when sea water is used for ballast.

Santolene C has also been proved effective in the laboratory and in product pipe-line service. Results have been confirmed through use by a major oil company which, for more than a year, has marketed all types of light petroleum products.

Santolene C is product-soluble. It burns completely with the fuel, leaving no residue. Diesel and gasoline engine tests have proved that Santolene C does not reduce engine cleanliness, causes no injector fouling, has no adverse effect on any factor of engine performance.

If you have a corrosion problem with light petroleum products in refineries, pipe lines, tanks, tank cars or tankers, Santolene C may solve it for you. For technical information on the use of Santolene C, write, wire or telephone MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1775-G So. Second Street, St. Louis 4, Missouri.

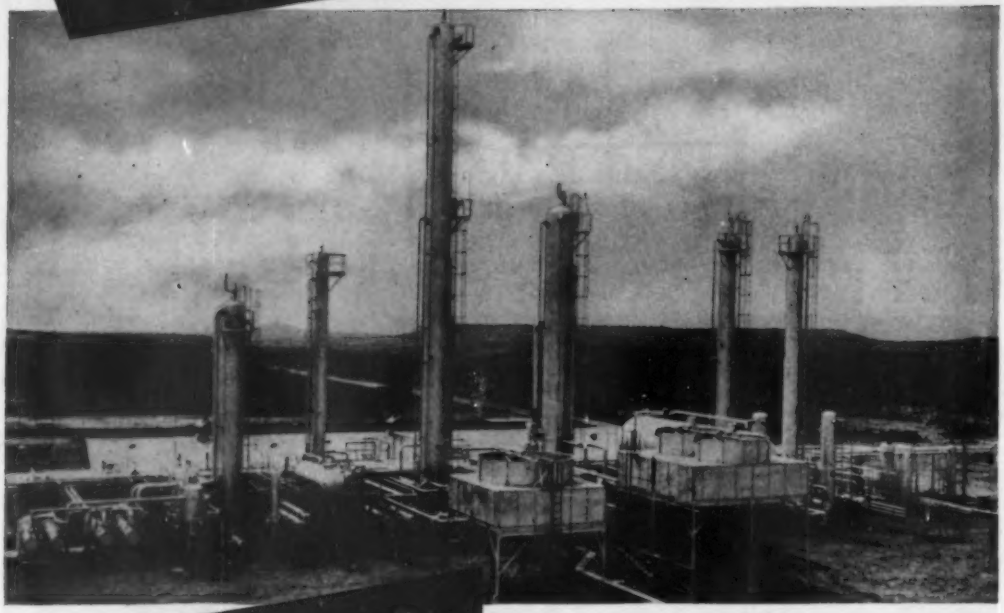
URGENT—If you have empty carboys or returnable drums, please return them to your supplier promptly. They're urgently needed. Containers are scarce!

Santolene: Reg. U. S. Pat. Off.

MONSANTO
CHEMICALS for PLASTICS

SERVING INDUSTRY . . WHICH SERVES MANKIND

Reduce Fouling in your plant



with **BROWN FINTUBE** ***sectional hairpin heat exchangers***

● Brown Sectional Heat Exchangers, with their integral one-piece extended surface fintubes, reduce fouling, just a few hundredths of an inch of which on a tube causes a major loss in heat transfer efficiency.

These exchangers assure efficient operation at low "skin" temperatures, minimizing coking and building up on the fintubes. And the controlled flow through the longitudinal passages keeps all the material in continuous motion. There are no baffles, back-eddies or stagnant areas to encourage fouling.

For top operating efficiency and reduced fouling use Brown Sectional Heat Exchangers throughout your plant. ***Write for Bulletin No. 481.***

THE BROWN FINTUBE CO.

Elyria, Ohio

Sectional Hairpin Heat Exchangers
Tank Suction and Line Heaters
Fintube Heaters for Bulk Storage Tanks
Indirect Process Air Heaters
Fintube Heaters for Processing Tanks
Integrally Welded Fintubes for Any Heating, Cooling or Heat Transfer Service

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IMPROVE CONTROL OF FLUID FLOW AND SHUT-OFF

24" stainless steel butterfly valve with Cono-Control air diaphragm operator and auxiliary hand wheel control; operation at high temperature.

20" rubber-lined butterfly valve with air cylinder and counterweight; for corrosive vapors at 215°F.

30" butterfly valve for 60 p.s.i. operating pressure; equipped with Jonette electric motor operator.

Pipe up to W. S. ROCKWELL Automatic Butterfly VALVES

For air, gases, liquids, semi-solids—corrosive or abrasive—hot or cold—at pressures to 100 p.s.i., Rockwell Butterfly Valves provide controlled flow and quick shut-off that's automatic and trouble-free.

Made in all pipe sizes to 72", any metal or rubber-lined; may also be manually controlled.

Ask to be put on list to receive monthly issue of the Valve News about Rockwell Butterfly and Slide Valves.

W. S. ROCKWELL CO.
250 Eliot St., Fairfield, Conn

the past 11 years he has specialized in fluid dynamics and the application of purifiers.

Michael J. Toth holds a mechanical engineering degree from Case Institute of Technology. In the field for ten years, he recently spent four years as assistant to the chief engineer of a Purifier manufacturer.

Weingard

Wiley

American Meter Names Wiley Weingard as Vice Presidents

American Meter Company announced the appointments of two vice presidents: Donald C. Wiley in charge of research, and Archie E. Weingard in charge of production.

Wiley, a Purdue graduate, joined American Meter in 1947 at its main research laboratory in Erie, Pa. Prior to that he served John J. Nesbitt, Inc. for six years as production manager.

Weingard, with the company since 1947 as supervisor of methods, was graduated from the General Electric Technical Engineering School and served GE for 16 years as foreman while conducting evening classes in tool designing at the Pennsylvania College Extension in Erie. From 1943 to 1947 he was superintendent of production control at Lord Manufacturing Company. He is an active member of the American Society of Tool Engineers.

Consolidated Quarters in Two Cities for American Cyanamid

American Cyanamid Company has consolidated its several office and warehouse locations in Chicago and St. Louis into one newly constructed building in each city. Open house ceremonies were held late in June.

The two moves are part of an over-all company plan which calls for other consolidations in major cities of the United States and Canada. With the new office and warehouse buildings in operation, the functions performed by the previous locations are handled by one staff under one roof in each city.

The Chicago building, a two-story structure with 100,000 square feet of floor space, occupies a site in the Addison Kimball district sufficiently large to permit future expansion. The St. Louis building is a one-story 30,000 square foot structure. Both buildings were designed and built to Cyanamid's specifications and leased to the company on a long-term basis.

Lysaght Named Sales Manager For Helicoid Gage Division

Vincent Lysaght was appointed sales manager of the Helicoid Gage Division of American Chain & Cable Company, Inc., recently. Lysaght previously directed the sales of the Campbell Ma-

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That WEATHERCOAT—

- TROWELS EASILY
- STAYS FLEXIBLE & TOUGH
- STAYS SEALED

Laykold

WEATHERCOAT PROTECTS

the insulation on your hot or cold vessels — for YEARS!

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MASTIC WEATHERCOAT — New and ready-mixed for void-filling scratch coat.

Ask for specifications and data.

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Washington 6, D. C. · Baltimore 3, Md. · Perth Amboy, N. J. · Columbus 15, O. · St. Louis 17, Mo. Baton Rouge 2, La. · E. Providence 14, R. I. San Juan 23, Puerto Rico · Mobile, Ala.

In the West
STANCAL ASPHALT & BITUMULS COMPANY
200 BUSH STREET · SAN FRANCISCO 4, CALIF.
Los Angeles, Calif. · Oakland 1, Calif. Portland 4, Ore. · Seattle, Wash. · Tucson, Ariz.

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TESTS PROVE PYREX GAUGE Brand GLASSES MOST ECONOMICAL

Proved to outlast any other gauge glass by a wide margin, PYREX brand cuts your maintenance costs to the irreducible minimum!

PYREX brand gauge glasses are highly resistant to chemical attack. They withstand severe physical and thermal shock. No other gauge glass, imported or domestic can consistently meet such tests.

Yet, PYREX glasses cost no more . . . and give longer service life. Economize today. Specify PYREX brand gauge glasses. Available through your Industrial Supply Distributor.

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CORNING, N. Y.

Reg. U.S. Pat. Off. PYREX

Gauge Glasses, Sight Glasses, Oil Cup and Lubricator Cup Glassware.

• 100 Years of Making Glass Better and More Useful •

chine Division and Wilson Mechanical Instrument Division.

Author and lecturer, Lysaght is a member of ASTM and the American Society for Metals. He is a graduate of M.I.T.

John Morrison, newly appointed product manager, will assist Lysaght in sales development activities.

Howard to Manage New Houston Office for Wall Colmonoy

A new Southwest office and warehouse was opened recently by the Wall Colmonoy Corporation at 5815 Clinton Drive, Houston.

Howard

Henry L. Howard, a sales engineer, on the staff of a large welding distributor in Texas for the past six years, was appointed manager of the Houston office. He was also a welding engineer for Goodyear Aircraft Company and Republic Steel Company, Cleveland.

Wall Colmonoy Corporation manufactures corrosion, wear, abrasion and impact resistant alloys.

Three ACF Men Are Relocated As Promotions Announced

American Car and Foundry Company recently named William M. Hawkins, George Reed and Sheldon Thomas for promotions.

Hawkins, formerly laboratory director at Berwick, has been appointed senior research engineer at New York. A graduate of both Harvard and Chrysler Institute of Engineering, he joined ACF in 1948 as a research engineer.

Reed, formerly manager of inspection, succeeds Hawkins at Berwick with the new title of manager, general laboratories. He was officer-in-charge of the A. O. Smith Naval Ordnance Plant during World War II and is a University of Michigan graduate.

Thomas was promoted from resident representative at the Chicago plant to manager of inspection. He has been a company employe since 1940, with posts in New York and Chicago.

Rockwell Appoints Bledsoe Chicago Sales Engineer

George G. Bledsoe, who was a sales promotional representative for the Pittsburgh Valve & Fittings Corporation in West Virginia, Wisconsin, Minnesota and upper Michigan before joining Rockwell Manufacturing Company, was appointed sales engineer of industrial accounts in the Chicago area.

Bledsoe spent his early years in Tennessee and Ohio before joining The B. F. Goodrich Company as Raw Materials Inspector in 1940. He holds a B.S. degree in general business from Akron University.

Worthington Names Murray New Compressor Division Head

Herman H. Miller, has resigned as manager of the compressor division of Worthington Pump and Machinery Corporation in Buffalo, N.Y. He will be succeeded by E. A. Murray. Miller, 50

FIRST EXAMINE . . .
THEN SELECT
THE GRATING
WITH ALL
5
SUPERIOR FEATURES!

1. STRONG electro-forged construction for easy installation.

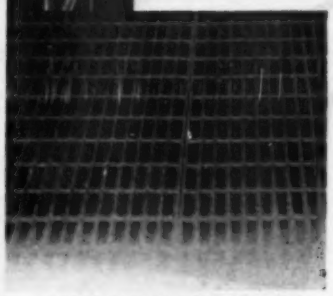
2. MAXIMUM OPEN AREA for light and air.

3. EASY TO MAINTAIN...paint reaches entire surface.

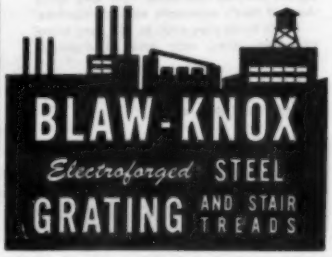
4. SELF-CLEANING, no sharp corners to clog.

5. SAFE footing at all times with twisted cross bar.

Write for complete specifications



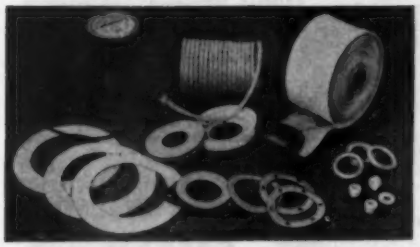
BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2005 Farmers Bank Building
Pittsburgh 22, Pa.



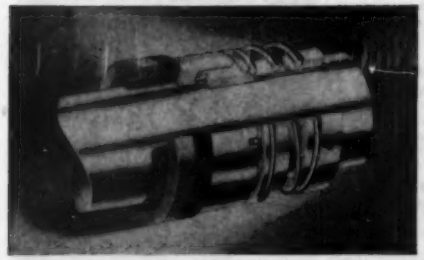
New and Improved

Packings, Gaskets and Seals

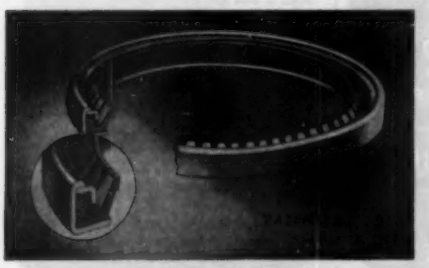
—from our expanded research program



Garlock Packings and Gaskets made of TEFLON



Garlock Mechanical Seals for Rotary Shafts



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Research has brought advanced design, better materials and new uses for thousands of products in American industry.

Here in the completely equipped Garlock research laboratories we have developed new products and have improved our regular line of packings, gaskets and seals with new materials and better designs.

These new and improved Garlock products will give you superior performance and long, economical service—will help you keep down operating costs.

Write for folders!

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PALMYRA, NEW YORK
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anti-corrosive
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Specify that your insulation be secured with the correct type of metal.
A. J. Gerrard offers:
7 TYPES
12 WIDTHS and THICKNESSES of each type
Also Tools for Applying.
FREE Handy calculator—one side tells you which strap to use for any given corrosive condition; the other side determines length and weight of strap required for any binding operation.
STEELBINDER Steel Strap CALCULATOR
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(Chicago Suburb)
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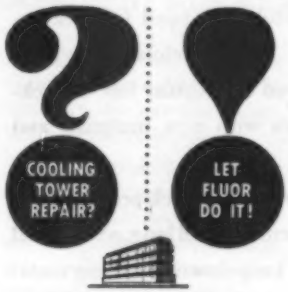

Whether your cooling tower is new or old—natural or induced draft—let a qualified Fluor Service Representative study your maintenance and repair problems—at no cost to you!
2 FREE SERVICES AVAILABLE
1 PREVENTATIVE MAINTENANCE — Fluor will recommend a preventative maintenance program based on operating conditions and locale—and then arrange for periodic inspections!
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Miller

Murray

years with Worthington, will be consultant to the new manager until he retires in December.

Murray holds a B.S. in M.E. from Yale and before joining Worthington in 1935 was associated for nine years with General Electric Corporation as an electrical consulting engineer for the compressor division and later as assistant manager. Murray is a member of the Engineering Society of Buffalo; Tau Beta Pi and Sigma Psi.

Earl C. Smith Joins Merritt-Chapman-Scott

Earl C. Smith, active for the 25 years in the fields of chemical plant and oil refinery design, construction and operation, has joined Merritt-Chapman & Scott Corporation, New York, as a sales engineer. He will work under Myles C. McGough, vice president in charge of the company's Industrial and Building Construction Division.

Smith has been identified with the construction and operation of chemical and process industry plants since his graduation from Iowa State College in 1926 with a BS degree in chemical engineering. Previous connections have been with Brown & Root, Inc., of Houston, as a sales engineer; with The Lummus Company, of New York, as a job and project engineer and Army service, when he helped design, construct and operate the Huntsville Arsenal at Huntsville, Ala. He is a member of the American Society of Mechanical Engineers.

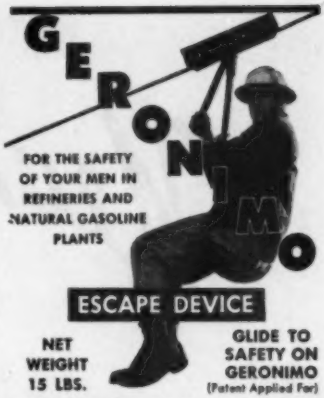
Milton Transferred to Boston

American Cyanamid Company recently appointed H. C. Milton as assistant district sales manager of the Industrial Chemicals Division at Boston, according to a company announcement.

Fairbanks, Morse Enlarges

A plant to manufacture engines and pumps is being built for Fairbanks, Morse & Company by Stone & Webster Engineering Corporation. Originally

EXCEL-SO SEPARATORS
Coalesce and remove all free water from light petroleum products.
WARNER LEWIS COMPANY
P. O. BOX 3096-D • TULSA, OKLA.


GERONIMO
FOR THE SAFETY OF YOUR MEN IN REFINERIES AND NATURAL GASOLINE PLANTS
ESCAPE DEVICE
NET WEIGHT 15 LBS.
GLIDE TO SAFETY ON GERONIMO
(Patent Applied For)

GERONIMO will stand hardest wear and give unfailing protection to refinery and derrick men whose lives are endangered by fire, escaping gases or other hazards.
EASILY ATTACHED OR REMOVED
EXTRA STURDY CONSTRUCTION
QUICKLY STRADDLED
POSITIVE, INSTANT BRAKE
BRONZE "No-Spark" SURFACES
RECOMMENDED FOR ½" WIRE LINE
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CHARLIE'S MACHINE WORKS
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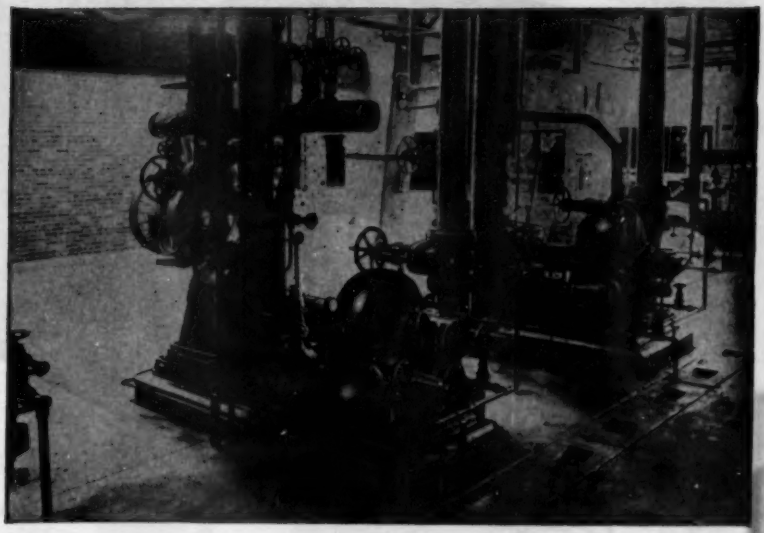
CHICAGO-WILCOX GASKETS
Proved in Service in the Refinery Industry
GASKETS FOR HEAT EXCHANGERS, COOLERS AND CONDENSERS
Gaskets cut from solid metal, sheet-packing, or double jacket type as needed.
Corrugated metal gaskets for refinery use. Made of ingot iron, Terne-plate, aluminum, stainless steel and monel in sizes from 1 inch up.
A.P.I. ring gaskets for high pressure lines for use on ring-type flanged joints. Made of soft iron and all standard steel alloys in oval and octagonal shapes.
See page 232 in the Refinery Catalog.
CHICAGO-WILCOX Mfg. Co.
7703 Avalon Avenue
Chicago 19, Illinois

TERRY



THE ROTORS OF THESE 75 H. P. TERRY TURBINES ARE DOUBLE RIM PROTECTED

The two 75 H.P. Terry Turbines shown above (in the plant of a leading refiner) employ the Terry Solid Wheel Rotor. The wheel is made from a single steel forging and the buckets are milled directly into the wheel. — All as shown in the illustration at the left.

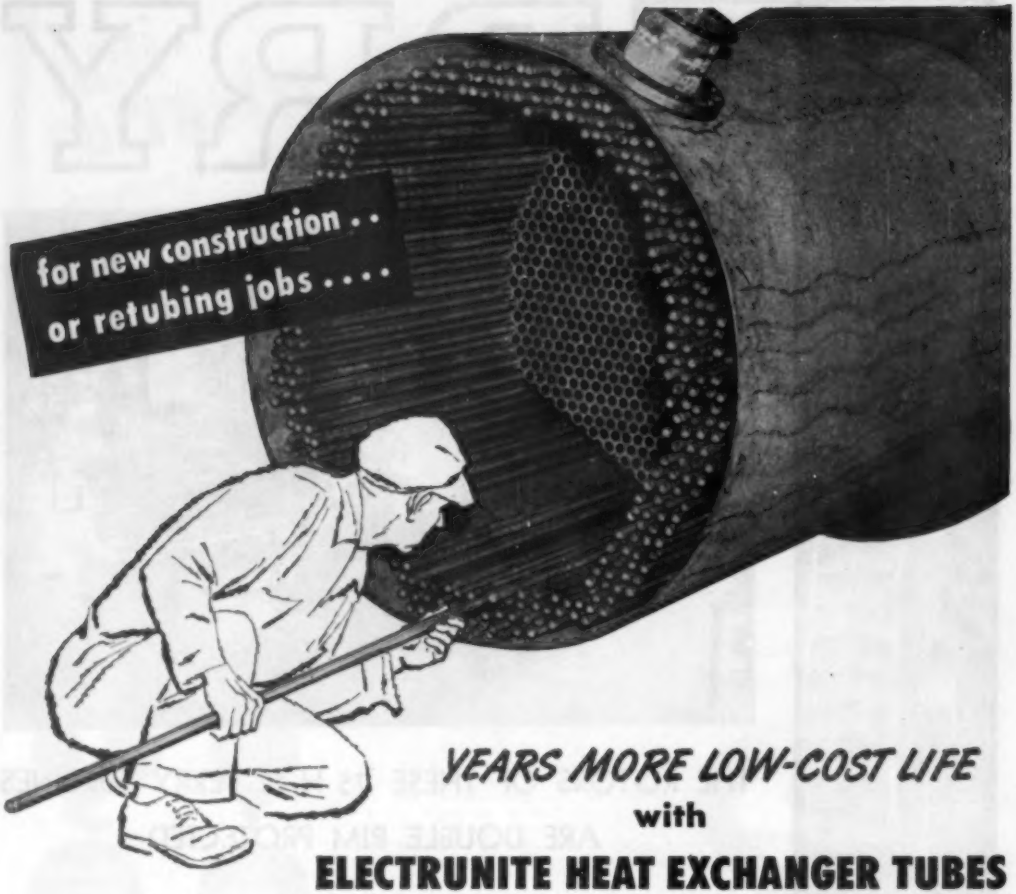
The buckets are protected by rims at the sides of the wheel. These rims would take without damage any rubbing that might occur if the clearance became reduced.

With this construction it is impossible for the blades to foul and frequent inspections of the thrust bearing are not required to obtain safe and dependable operation.

This feature and many others of the Terry Wheel Turbine are fully discussed in our Bulletin S-116.

T-1169

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.



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ELECTRUNITE HEAT EXCHANGER TUBES

Increase the years between retubings . . . cut the per-hour cost of exchanger operation . . . specify ELECTRUNITE Pressure Tubes for new equipment . . . and for all your retubing jobs.

Fully-normalized structure provides uniform ductility for fast, smooth roll-in of ELECTRUNITE Tubes. Cold forming gives them clean, scale-free surfaces that assure maximum service life. Choose from a wide range of sizes and grades, in carbon steel and stainless steel analyses. For complete data and information, write to

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planned as a scale plant it was enlarged to include a foundry. Located near Kansas City, Mo., the plant is estimated to cost $7.5 million inclusive of machinery and equipment. Scale manufacturing operations now carried on at St. Johnsbury, Vt., and Moline, Ill., will be expanded.

Worthington Moves Water Section to Harrison Plant

Sales and engineering functions of the Water Treating Section of Worthington Pump and Machinery Corporation were moved recently from the company's Dunellen, N. J. plant to its Harrison, N. J. plant. J. F. Sebald continues in his capacity as head of the engineering department and A. L. Jones retains responsibility for sales functions.

Diamond Alkali Will Expand Dallas Silica of Soda Plant

Diamond Alkali Company, Cleveland, Ohio, has announced plans for an expansion project at its silicate of soda plant at Dallas.

W. H. Evans, the company's general manager of silicate operations, stated that the new project, estimated to cost several hundred thousand dollars, calls for the installation of a large furnace to supplement the production of three smaller-type furnaces now in operation. The present furnace building will be remodeled to accommodate the expanded facilities.

The Dallas plant is one of six silicate plants Diamond operates throughout the country. It has 12 plants in all.

Tempil° Names Distributor

Tempil° Corporation has added Southern Oxygen Company, Inc., Washington, D. C., as a distributor of its line of temperature indicating materials. Tempil° products are now stocked by Southern Oxygen's 14 district offices (located in Pennsylvania, New Jersey, Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Tennessee and District of Columbia) and will also be available from Southern Oxygen distributors.

Du-Co Expansion Complete

Expansion of floor space by Du-Co Ceramics Company of Saxonburg, Pa., will be increased by 600 percent when construction is completed this month. Established in 1949 for the manufacture and sale of Steatite, electrical and refractory porcelain and other ceramic compositions for special applications, Du-Co at present has complete facilities for mixing, pressing, extruding, drying, firing and machining ceramic parts.

Maxwell Sent to Washington

W. H. Maxwell recently assumed his new duties as assistant to the vice president for the Wolverine Tube Division of Calumet and Hecla Consolidated Copper Company, Inc. He will maintain residence in Washington to work with government control agencies, and on brass mill industry contacts. Maxwell was formerly director of sales. G. D. Potter, general sales manager, will carry on Wolverine sales activities.

Valve Manufacturer Moves

Manning, Maxwell and Moore, Inc. headquarters formerly located in the

R·P&C
VALVES
NO. 1030
Stainless
Steel
Bar Stock
Valve
R-P&C Bar Stock Valves are an achievement of the valve makers' craft. They are precision turned . . . from carefully tested metals . . . and suitable for a wide range of pressures and temperatures . . . for meter, gauge, test, and general purposes.
● Rugged construction of R-P&C Bar Stock Valves means long, low-cost, trouble-free service. No better bar stock valves are made. See your R-P&C distributor today or write the nearest R-P&C district office for information.
R-P & C VALVE DIVISION
AMERICAN CHAIN & CABLE
"Intentionally Better"
READING-PRATT & CADY VALVES

Whiton— SOLID STEEL ROTOR
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ASSURES . . .
LONGER, EFFICIENT OPERATION

ELIMINATES . . .
COSTLY BREAK-DOWN AND REPLACEMENTS

Designed to your specific requirement.

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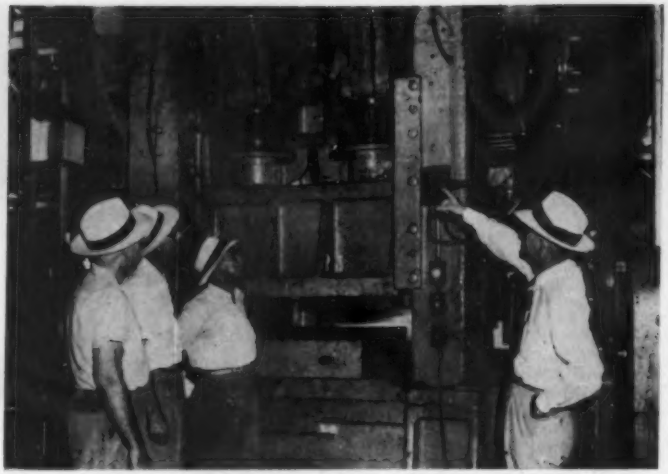
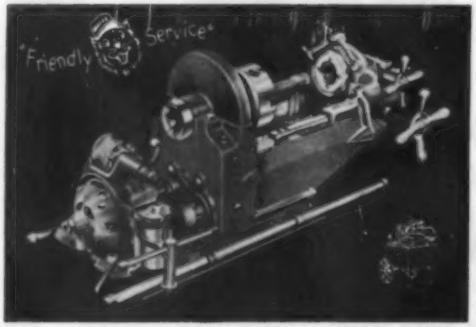


NEW PLANT OPENED—Features of a huge blanking press in the newly operating United States Steel Products Company plant at Port Arthur, Texas, are pointed out by John C. Daugherty, right, manager of Texas plants for the company. The company, a subsidiary of United States Steel, opened the plant recently after moving more than 100 heavy pieces of machinery from Beaumont. In addition more than 50 new machinery units were added to the production setup in the new plant which manufactures steel containers for the petroleum, chemical, etc., industries. Left to right: W. H. Ford, superintendent of the Port Arthur plant; A. E. Djerf, construction engineer, Consolidated Western Steel Corporation, builder of the plant; and C. E. Vanderholt, assistant to the district manager of United States Steel Products Company.

Chrysler Building, New York, will move to the new Chrysler Building East about November 1. The move concerns Eastern sales district headquarters for the concern's Consolidated Ashcroft Hancock Division and Shaw-Box Crane and Hoist Division, as well as headquarters for its expanded export branch.



Users Say: **"MODEL-A BEAVER CUTS COSTS"**

● For 17 years Model-A Beaver Pipe & Bolt Machine (⅛" to 2" portable) has proved its worth, cut costs and increased output, because—

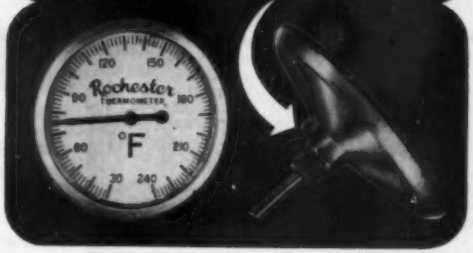
"... cost has been cut to a fraction"—Spitzley Plumbing & Heating Company.
"... repairs are negligible"—Advance Heating & Air Conditioning Corp.
"... over-all merit"—The Monarch Cement Company.
"... disposed of all other machines"—The Lane Company.
"... more than earned their cost"—Barnstead-Wolford Company.
"... saves us much time"—Lehigh-Navigation Coal Company.
"... trouble-free, timesaver"—Celanese Corporation.
"... withstands hard usage"—Grinnell Company.

Thousands of Model-A's are in use throughout the world. We back them up with 51 years of experience and friendly service.

Write for new Catalog C.C.-51. Address Beaver Pipe Tools, Inc., 252-300 Dana Avenue, Warren, Ohio, U.S.A.

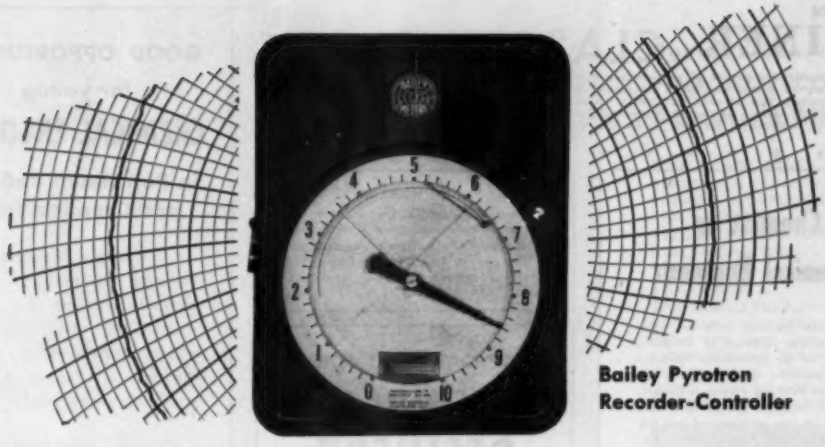
BEAVER
PIPE TOOLS
252-300 DANA AVE. WARREN, OHIO, U.S.A.

RECALIBRATE *on the job—*
Rochester
DIAL THERMOMETERS



Accidents are bound to happen . . . like dropping or banging a thermometer sufficiently hard to make readings inaccurate. This could result in costly production errors. To eliminate this possibility, Rochester now offers a new bi-metallic Dial Thermometer with screw adjustment permitting recalibration on the job! Simply put the instrument in boiling water or other known temperature and reset indicator. Better order today. Send for Catalog No. IT-650, Rochester Manufacturing Co., Inc., 38 Rockwood St., Rochester 10, N. Y.

ROCHESTER
MANUFACTURING COMPANY, INC.
DIAL THERMOMETERS · GAUGES · AMMETERS
ROCHESTER GAUGES



Bailey Pyrotron
Recorder-Controller

Looking for Better Temperature Instruments?

. . . Then check these features of Pyrotron Electronic Resistance Thermometers . . .

FUNDAMENTAL ACCURACY

Bailey Pyrotron Resistance Elements are made of highest purity platinum—the material used by the National Bureau of Standards in establishing basic standards for temperatures from −190°C to +660°C.

THREE TYPES OF CONTROL

Pyrotron Controllers may operate: on-off electrical systems by either electronic relays or electric contacts, modulated electronic systems, or air-operated systems. Two temperatures may be recorded on the same chart and controlled by a single instrument.

FACTS PUT INTO USABLE FORM

Bailey Pyrotrons may be arranged to put temperature facts into convenient usable forms. If two or more temperatures are related, they may be recorded as continuous records on the same chart for easy comparison. The average of several temperatures or the difference between two temperatures may be recorded as a single continuous record which may be retransmitted to a distant point or used to actuate a control system.

EASY INSTALLATION

Bailey Pyrotrons do not require careful leveling or protection against vibration. Three ordinary copper wires are all that is needed to connect each temperature sensitive element with the recorder. Power may be taken from any 115 volt 60 cycle circuit.

MINIMUM MAINTENANCE

The absence of galvanometers, batteries and standardizing equipment, together with the use of interchangeable unit assemblies, reduces Pyrotron maintenance to the vanishing point.

ABUNDANT POWER

A separate motor drive for each temperature furnishes abundant power to operate a recording pen, a controller and an alarm switch.

For the full story on this unusual electronic resistance thermometer which is suitable for ranges between −300°F and 1200°F, ask for Bulletin No. 230-C. P-21

BAILEY METER COMPANY

1043 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Processing

TEMPERATURE
PRESSURE
% OXYGEN
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FLOW
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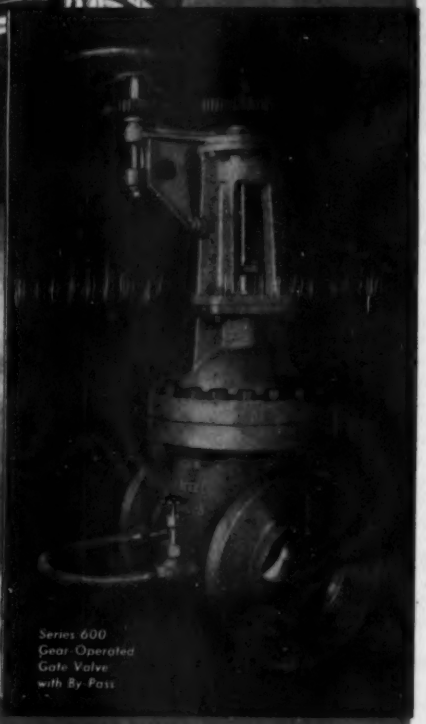

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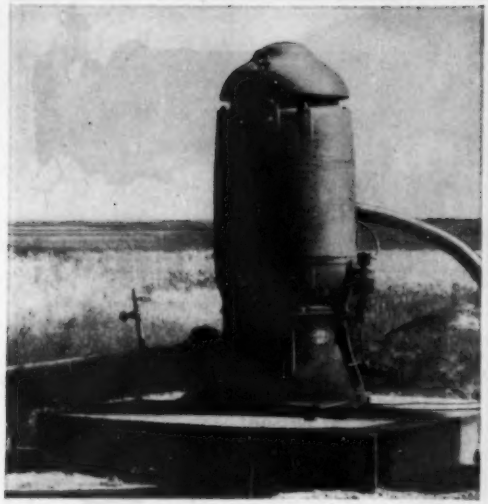

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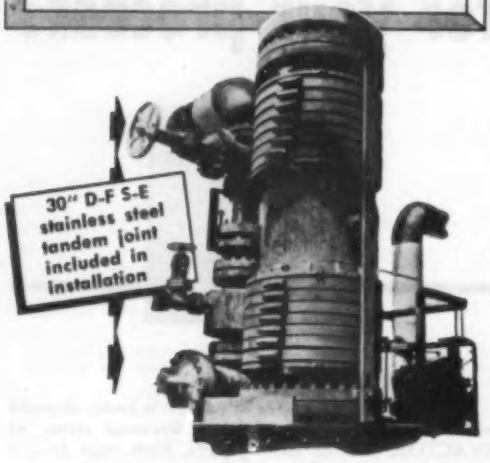

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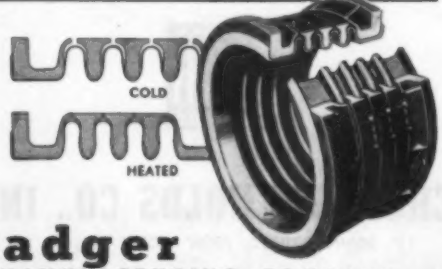

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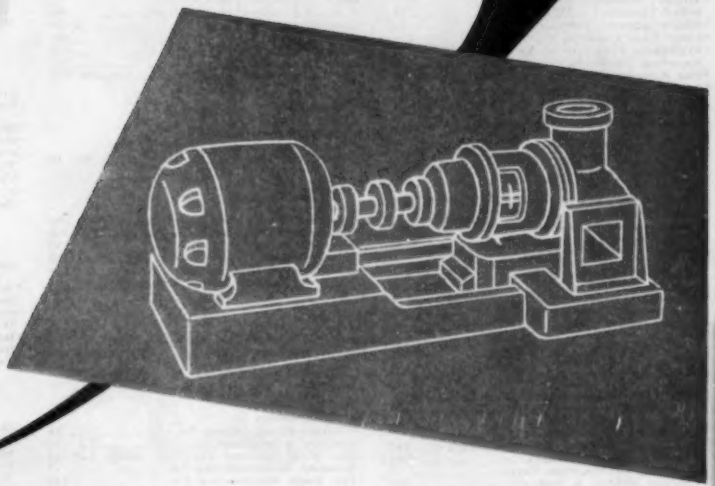

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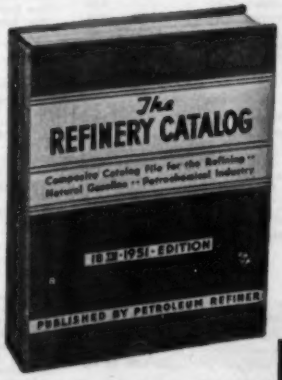
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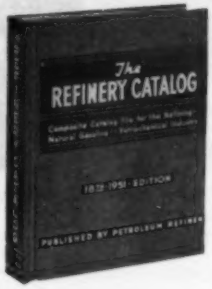

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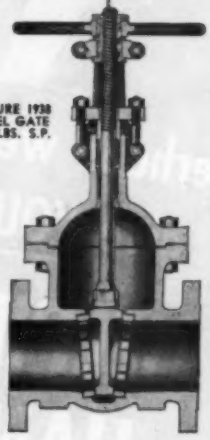

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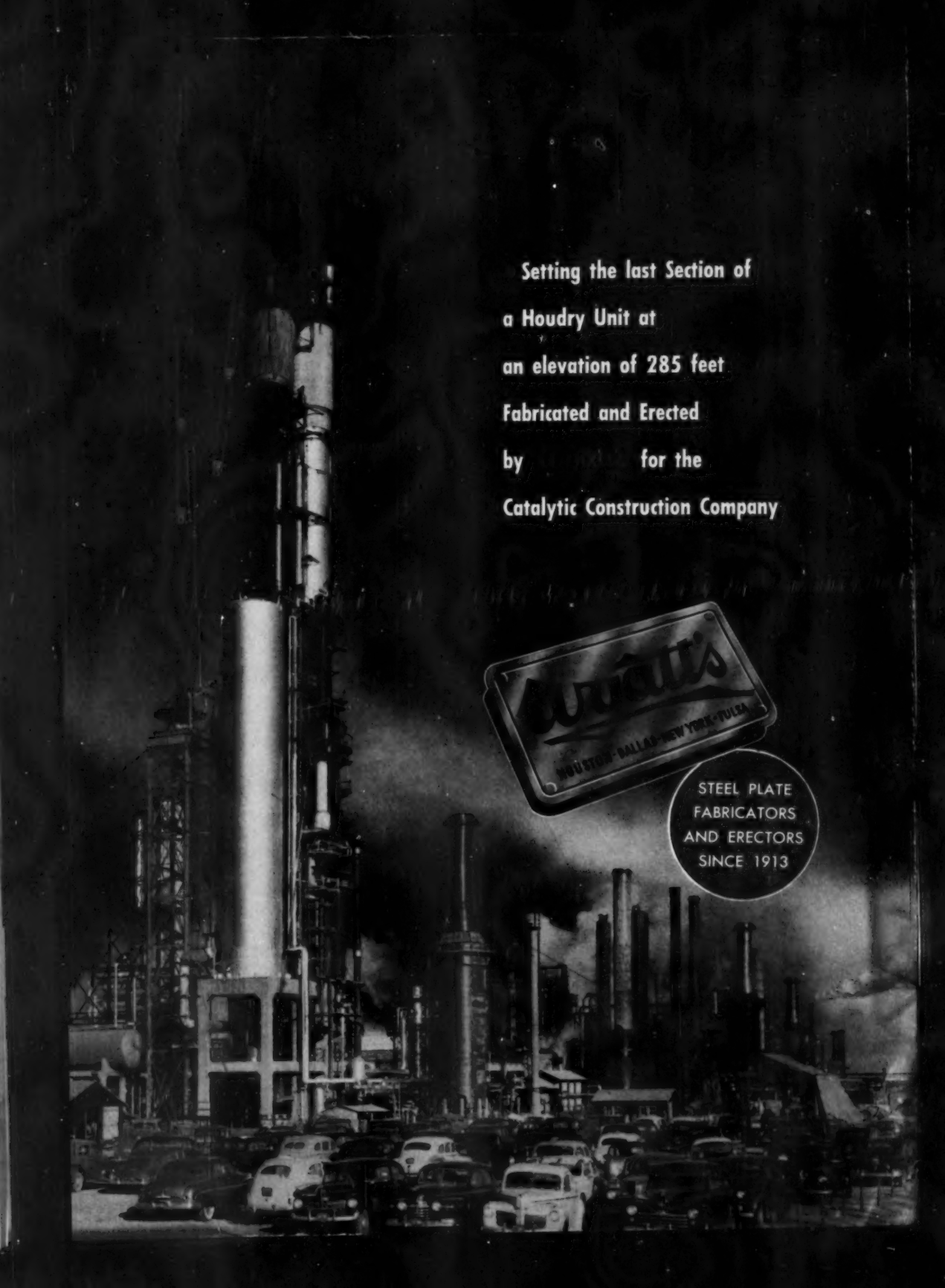
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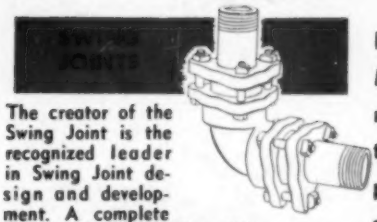
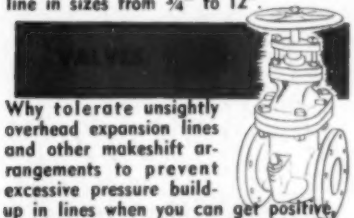
Your Logical FIRST Choice for Oil Handling Equipment

BACKED BY 95 YEARS OF MANUFACTURING EXPERIENCE



The creator of the Swing Joint is the recognized leader in Swing Joint design and development. A complete line in sizes from ¾" to 12".



Why tolerate unsightly overhead expansion lines and other makeshift arrangements to prevent excessive pressure build-up in lines when you can get positive, automatic protection with the McDonald 4" Expansion Relief Gate Valve?

Balanced design, special features, introduce a new standard of loading efficiency. The development of years of special study of loading problems.

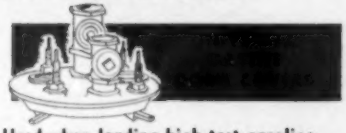
For nearly 100 years the McDonald reputation has rested on a solid foundation of completely reliable products—products that combine the latest in engineering with an extra measure of sturdiness that means a generous bonus of service. Where else can you get such positive assurance of the results you look for in oil handling equipment?

A. Y. McDONALD MFG. CO.

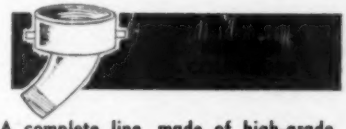
The Home of the Swing Joint

DUBUQUE, IOWA

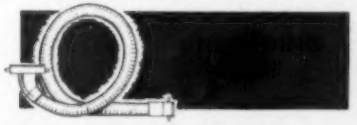
There's a McDonald Branch or Distributor Near You



Used when loading high-test gasoline—reduces evaporation losses—permits loading rain or shine—eliminates danger of sparks. Saves 2 to 8 barrels of gasoline per car loaded.



A complete line, made of high-grade bronze. Accurate threading assures tight connections. Shipped complete with treated leather gasket and forged steel spanner wrench. Sizes, 5 x 2, 5 x 2½, 5 x 3, 5 x 4 in.



Galvanized flexible steel tank car unloading hose available in 2", 2½", 3" and 4" sizes and in any desired length, complete with couplings.

These Are Representative Items from a Comprehensive Line of Oil Handling Equipment. Write for Catalog.

McDONALD